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COAT COLOR GENES IN RODENTS AND CARNIVORES

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INTRODUCTION

ANY comparative review of coat color genes in mammals faces unavoidable difficulties. Only a few species have been studied sufficiently to provide enough information for accurate analysis on which genetic similarities or differences between species can be determined.

There are at least four types of evidence that will help to estimate the probability of interspecific homology of genes. These will be referred to in discussion of loci in each group.

These types of evidence are as follows:

(1) similar linkage relations between two or more genes;
(2) similar pleiotropic effects of genes;
(3) similarity of multiple allelic series; and
(4) similar morphogenesis and function of melanoblasts.

The interspecific homology of genes or loci will, however, remain to some degree uncertain unless direct evidence from interspecific crosses is available. It seems proper, therefore, to list under each species the genes and loci recorded in it, and later to discuss under the loci the points of similarity and dissimilarity which comparison between species reveals.

There seems to be little question that the basic chemical processes underlying melanin pigment formation are similar in rodents and carnivores. It is undoubtedly more than a coincidence that three, and only three, pigments (yellow, brown, and black) are found in the coats of each group.

It is also important to note that in all the species observed yellow pigment formation and distribution may, under certain conditions, be affected by genes, independently of the brown-black pigments. The opposite is also true, and one finds genes which appear to act only on brown-black and not on yellow.

To a large degree also the basic origin and morphogenesis of melanoblasts appear to be the same in both groups. There may be in carnivores (at least in the Felidae) a skin pattern involving structural differences which is a phenomenon absent or as yet unrecorded in rodents.

This condition has been described in the domestic cat by Pocock (1907), who noted that the black bands in "striping" and "blotching" were underlined by thicker skin than were the areas which remained light (tawny) as the pigment developed. The presence of skin areas of this type may be the reason for the so-called "ghost patterns" which sometimes appear in newborn or young black animals and which disappear during the uniform distribution of dark pigment or by the replacement of the juvenile dark pigment by yellow at a later age. This matter will be further discussed when the color genes of cats and dogs are considered.

Over a number of decades, efforts have been made to utilize genetic experimentation to help to elucidate the chemical and morphogenetic factors and processes underlying the formation and distribution of melanin pigment in mammals.

In genetic studies, the house mouse has had the longest and most important role. From the obviously primitive efforts of the writer (1913) to classify coat color genes, through the much improved analysis by Wright (1917), and up to the

last decade, the progress has been slow. Since 1943, however, a series of histological studies by Russell (1939, 1946a, b, 1948, 1949a, b) has greatly advanced our knowledge of the genetic variation in formation, morphology, and distribution of pigment granules in the hair. Such work as that of Danneel and Schaumann (1938) has advanced our knowledge of chemical processes; and the really pioneer work of Markert and Silvers (1956) has opened the way for morphogenetic analysis of gene and developmental factors.

It is purely a matter of choice as to how far and in what order we should, in a very general paper of the present type, discuss these aspects of the comparative genetic problem. The "comparative" utilization of the most recent discoveries in any *one* species of rodent must, obviously, await further research with other species. We shall, therefore, present only a very brief discussion of these fundamental researches to serve as a reference point for more complete and extensive comparative evaluations between species to be made by others in the future, as data are accumulated.

Russell (1949a), in an exhaustive study of interdependence among the various attributes of melanin pigment granules in the mouse in the production of coat color, recognizes the following factors:

(1) The nature of granule color, which determines also the upper limits of the number of medullary and cortical granules and also limits the extent of variation in granule size.

(2) The size of pigment granules, which controls their shape, color, and density of distribution.

(3) The degree of pigmentation, which is a complex of attributes varying simultaneously. This complex includes medullary granule number, granule size, granule shape, and color intensity in the black-fuscous types. The tendency towards distal arrangement also is a factor.

(4) Granular clumping.

In discussing the nature of genic substitutions in five major allelic series of the mouse, Russell (1949b) has commented as follows.

The agouti series (*A* locus) genes appear to control a trigger mechanism which causes a reversible shift from the formation of a eumelanin (black-fuscous or brown) to formation of a xanthin type of pigment (yellow) within the space of one or two medullary cells.

The *B-b* pair of alleles causes a qualitative change in the eumelanic regions from black-fuscous to brown.

The *C* series consists of purely quantitative levels suggesting that these alleles control the amount of some substance which is necessary for all color types.

The *d* alleles cause irregular pigment deposition resulting in clumps of granules and in the reduction in amount of medullary pigment.

The *p* genes affect the size of eumelanin pigment granules and the degree of pigmentation.

Later work (1956) by Markert and Silvers on the effects of the genotype and of cell environment on melanoblast differentiation in the mouse discusses the methods and levels of gene activity in a most interesting and stimulating manner. These authors have provided a constructive analysis of the basic factors in melanin pigment formation and distribution. They recognize (1) that the genetic make-up of the individual determines the limits and potentialities of over-all pigment formation; and (2) that diverse cellular environments, resulting from cellular activity, elicit responses which produce a wide variety of cells.

The melanocytes or cells in which pigment appears are influenced in their activity and function by four factors:

(a) the genotype of the melanoblast; (b) the genotype of the environmental cells; (c) the environmental history of the melanoblast; and (d) the differentiated characteristics of the environmental cells.

Using a large number of alleles in some 19 loci of the house mouse, an effort will be made (1) to relate these various characteristics to the embryonic history and genotype of the melanoblast, and (2) to formulate an interpretation of melanocyte differentiation based upon gene action within the melanocyte and within the environmental cells.

Among the genes acting within the melanoblast, these authors list those situated at the following loci: *A* (A^w and a^t); *B* (*B*, B^{lt}, and *b*); *C* (*C*, c^{ch}, c^e, c^a); *D* (*D*, *d*); *M* (*M*, *m*); *P* (*P*, *p*); *SI* (*SI*, *si*); *SP* (*SP*, *sp*); *RU* (*RU*, *ru*).

The *A* and *B* series act during the polymerization of melanin; but while A^w and a^t have been recognized as being active both within the melanoblast and through the cellular environment, the alleles *a*, *A*, and A^v are at present listed as active only in the latter way.

The *C* series is concerned with tyrosinase synthesis in the granules. The *p* and *ru* mutations affect the basic protein structure of the melanin granule. The genes *d* and *m* deal with melanoblast morphology, while those for splotch, *SP*, and for

silvering, *si*, appear to act on early steps in melanoblast differentiation.

One can easily see that there is a sufficient number of levels of activity and of biochemical pathways to afford opportunity for many distinct categories of gene activity in the formation of melanin pigment.

The same authors have given a list of genes which appear to act through the cellular environment in contradistinction to the first group. Included in this list are *bt*—belted; *f*—flexed tail (white belly spot); Mi^{wh}—dominant white; s^p—piebald spotting; *Sl*—slate; *To*—tortoise shell; *tp*—taupe; *Va*—varitint waddler; *W*, W^s—dominant spotting; and *gl*—grey lethal.

This excellent research leading to progress in understanding the action of most of the familiar color genes of mice should be continued and be supplemented by further efforts to define and classify the activity of such genes as *ln*—leaden; *pa*—pallid; *pe*—pearl; *ck*—chalky; *Ph*—patch; and *te*—lighthead.

Analyses similar to those of mouse genes should also be made, if possible, in rats, rabbits, and guinea pigs, all of which are species in which there are sufficient genes to offer a chance for comparative evaluation. Wright and Braddock (1949) have begun analysis of this sort in guinea pigs, but much more needs to be done. Until such analyses are made, comparison of mouse genes with those of other rodents must be largely by analogy.

LISTING OF COAT COLOR GENES

Using the house mouse as the basic rodent genetic type the loci which seem to be most important will be listed and discussed for this species and for other rodents. The results will then be tabulated for comparison.

Rodents

1. Genus *Mus*—old world mice and rats.

A. *Mus musculus*—house mouse.

This species, which has been studied genetically more intensively and extensively over a longer period than any other rodent, will be used as the type to which other species will be referred comparatively, in respect to coat color.

There are a number of compendia covering this field. The more important are Grüneberg (1952) and *The Mouse News Letter* (1949–1956). By reference to these, the reader may trace the literature relating to the origin of the various individual gene mutations which have been recorded.

The *A*, agouti, locus, at which there are at least five and probably six alleles, has given evidence of relatively frequent mutation. The top member of the allelic series is yellow, A^y, which is lethal when homozygous. The eyes are dark and the coat is ordinarily clear yellow. Dark (brown or black) pigment may, however, be present. Incomplete dominance of A^y, or darkening modifiers, may produce "sooty" yellows which may, in their extreme form, be hard to distinguish from dull-colored black and tan, a^t, animals.

The second member of the series is A^w, white-bellied agouti. There is a decreased amount of dark pigment on the dorsal and lateral surfaces. The ventral surface has white-tipped hairs with some dark pigment at the base. This mutation has been repeatedly observed in wild individuals.

In the middle of the allelic series is *A*, the "wild type" coat color, grey-bellied agouti. Black and tan, a^t, hypostatic to *A*, is the next member. The dorsal and lateral surfaces are dark pigmented, with no trace of the "agouti" pattern. The ventral surface is yellow (cream to deep yellow) with a clear line of demarcation separating it from the dark-pigmented areas.

The next member of the series is non-agouti, *a*, in which, with the exception of small light-colored areas behind the ears and around the anus, the whole coat is solid dark-pigmented (black or brown).

Very recently a sixth allele has been added (*Mouse News Letter* No. 15). It is extreme non-agouti, a^e, at the bottom of the allelic series. In it the tufts of light hair behind the ears and around the anus are replaced by black in *B* animals and by brown in *b* individuals.

A number of other genes which modify the expression of one or more of the *A* series of alleles have been described. Eaton and Schwarz (1946) described "Snowy belly," which they considered as an allele in the *A* series between A^y and A^w. They obtained, however, in an F_2 of snowy $\times$ a^t some white-bellied blacks, suggesting the "snowy" might be due to a gene linked with *A* and not allelic to it. Falconer (1947) in further studies found evidence of multifactorial and not single gene heredity. For the present, therefore, modifying genes seem to be the most likely explanation for this coat color.

Mather and North (1940) described a gene "umbrous," *U*, which makes *Aa* and *AA* much

darker, especially the former type. The writer and Dickie (unpublished data) have been studying a darkening gene which we have tentatively called "mahogany," *mh*. This gene makes A^v mice "sable," and may explain the genetic nature of that variety, which has been studied by a number of investigators over many years. Mahogany is independent from *A* and produces *aa* mice which appear to be phenotypically identical with a^ta^t individuals. "Dark," (*da*) which makes *A* or A^v individuals phenotypically like *aa* mice, has been discovered at Edinburgh (*Mouse News Letter*, No. 15, July 1956). It is interesting that the effect of *da* "wears off" in *A* mice with increasing age.

It is not surprising that the agouti pattern in its various alleles is easily affected in its expression. It is a serial and cyclic process with competing or alternating pigment-forming activity between black (brown) and yellow. As such, the balance representing the "typical" relationships between the two types of pigment should be and is disturbed by many factors, both genetic and environmental.

At the *B* locus there were, for many years, only two recognized alleles. Recently, Miller and Potas (1955) have added two more. The present series is *B*—black pigment, which is epistatic to b^e, "cordovan." The bottom member of the series is *b*, brown. The allelic status of "light brown" B^{lt} is not fully established, and there are some interesting theoretical questions which need investigation as to just where and how the gene acts.

At the *C* locus there are four well-established alleles. The top of the series is *C*, full pigmentation. Next comes C^{ch}, chinchilla, in which the amount of all pigment is reduced, but in which the effects of the reduction are ordinarily much more easily observed in the yellow pigmented areas than in the brown or black pigmented areas. Extreme "dilution," c^t, reduces pigment still further in a clear and striking manner. Finally, at the bottom of the series is c^a, "complete albinism."

The "Himalayan" type of albinism in which the animals are usually white with dark nose, ears, and feet has at least once appeared as a genetic mutant in mice (Mohr, 1939). It occurs today merely as a museum specimen, having been lost as a genetic variety.

The gene for intense pigmentation *D* has mutated to *d* "blue" dilution, and recently a third gene hypostatic to both has been described. This is dilute lethal, d^l (Searle, 1952). Clumping of pigment granules is a characteristic of the *d* and d^l mutations.

There are a number of other independent genes in mice which produce paling or dilution of pigment. One of these, *ln*, leaden, also has some clumping of pigment granules, although it is independent and distinct from *d*. Misty, *m* (Woolley, 1941), is another form of "dilution," but with no clumping and with two interesting forms of expression, one a white tail tip and an occasional white belly-spot, and the other a tendency to allow relatively more pigment in the extremities than do either *ln* or *d*. Other diluting and paling genes will be discussed later. The chance of demonstrating homology between these genes and those of other rodents is remote, unless and until breeding of other rodents in much larger numbers and under genetic control is carried on.

The *E* locus in mice is apparently a very interesting one. There is no record of the E^D mutation. There is one somewhat questionable description of what may have been the *e* recessive yellow mutation (Hagedoorn, 1912).

Relatively recently five types of blotched or mottled coat patterns with scattered areas of black and yellow (to light cream) pigment have been described. These are "brindled," *Br* (Fraser, Sobey, and Spicer, 1953); "mottled," *Mo* (Fraser, Sobey, and Spicer, 1953); "tabby" (Falconer, 1952); "tortoise shell" (Dickie, 1954b); and "dappled" (1956, *Mouse News Letter* No. 15, Harwell), located on the X chromosome and dominant.

Recent work (*Mouse News Letter*, No. 15, 1956) shows clearly that brindled and mottled are alleles. Tests with tabby, dappled, and tortoise shell should be made to determine their relationship to the M^o locus.

If these genes are in any way comparable to the "Japanese" gene in rabbits and to the tortoise gene in guinea pigs, they are alleles of *E*. If this is the case, the lethal action of unbalanced *E* alleles might extend from the e^t gene, producing tortoise shell, to the *e*, or recessive yellow mutant gene, and this type would therefore never be seen, since *e*XY males would die and this would prevent the formation of *e*X*e*X female individuals.

Since, however, it appears that the postnatal lethal effect of *Br* allows the development of *Br*XY to a point where they can be identified as *white*, not yellow, it seems likely that the four sex-linked genes which produce some type of "mottling" are more nearly comparable to a sex-linked *W* mutation than to one at the *E* locus.

Grizzled (*gr*) was described (1950) in *Mouse*

News Letter No. 2, from Edinburgh. It has "nearly the same effect" as chinchilla, C^{ch}. The yellow pigment becomes white but the black pigment is not visibly affected. It is recessive and is not in the *C* series of alleles.

The "pink-eyed" *p* mutation, which reduces markedly the amount of black or brown pigment and leaves the yellow practically untouched, has been long known in mice. The commonly described type is the middle member of a triple allele series, with *P*, full pigmentation, at the top and p^r, a Japanese ruby, at the bottom.

A type of pigment reduction "taupe," *tp*, was described by Fielder (1952). In the genetic tests made, no cross-overs were obtained between the new mutant and the *P* locus. It is therefore not certain whether taupe, *tp*, is at a separate locus or is an allele of *p*. The females are unable to nurse their young because of lack of development of the nipples.

"Pearl," *pe*, another independent recessive dilution gene affecting all pigments of both coat and eyes, has been described by Sarvella (1954). The females have a tendency to die during pregnancy or lactation, and even if they survive, make poor mothers.

"Pallid," *pa*, first described by Roberts (1931), is also a pigment-reducing gene in both coat and eyes, as is pink eye, *p*. It is not in the same chromosome, however, and it reduces all types of pigment in contrast to *p*, which does *not* affect yellow.

Piebald spotting (*s*) at the *S* locus is one of the earliest mutations to be recorded. A comprehensive study of various types of spotting was made by Dunn et al. (Dunn and Charles, 1937; Dunn, 1937; Dunn, MacDowell, and Lebedeff, 1937; Dunn, 1942). The isolation of stocks breeding true to dark, medium, and all white spotting was reported, as was the isolation of "white-faced" and "belt" stocks, with localized spotting. "Blaze" mutants (*bl*) and "light head," *le*, were reported as distinct from the *S* locus (Pincus, 1931; in *Mouse News Letter* No. 2, 1950) and "belted" spotting by Murray and Snell (1943). In addition, a spotted series called the "K" complex was described by Dunn and Charles (1937). It appears probable that there are certain allelic levels of activity at the *S* locus and that with careful control of independent spotting genes and of modifiers of *S* and *s* these might be recognized as they have been in rats (q.v.).

Silvered, *si* (Dunn and Thigpen, 1930), a form in which variable numbers of white hairs are scattered among the pigmented ones, is a recessive with a very wide range of expression from a few white hairs to a predominantly white roaning effect.

Steel (*Sl*), which is a dominant dilution of all pigments, with a white nose tip, forehead spot, and mid-ventral spot, was discovered by Sarvella (*Mouse News Letter* No. 6, 1952). The two last-named characteristics show incomplete penetrance down to zero in outcrosses. Homozygous *SlSl* animals die in utero near the end of pregnancy. They appear to be anemic. In crosses with *Wv*, the F_1 *Slsl Ww* mice are viable.

Splotch (*sp*) was described by W. L. Russell (1947). It is a dominant white ventral spotting, with occasionally a dorsal white spot as well. The homozygotes die, usually at about the fourteenth day of embryonic development. Spina bifida, kinky tail, and perhaps other abnormalities are found in the lethal homozygotes.

Varitint waddler, a dominant blotched or "merle" pattern with irregular contrasting areas of intense pigmented, dilute, and white hairs, was described by Cloudman (1945). The homozygotes are white except for small patches of pigment at the base of the tail or near the ears. They are also deaf (see merle, *M*, in dogs).

Dominant spotting *W*, associated with anemia and often with lethality or lowered vitality of homozygotes, occurs in two well-studied and two recent allelic types. The *WW* type is lethal as a homozygote; W^vW^v has viable homozygotes. The *WW*, WW^v, and W^vW^v forms are black-eyed whites

In 1956, a dominant spotting W^a was recorded (*Mouse News Letter*, No. 15, Ames, Iowa). It resembles *W* and has lethal homozygotes. In the same *News Letter* another allele of *W*, W^i, was reported from the Jackson Laboratory. There has not, as yet, been time to work out the exact order of epistasis for the whole allelic *W* series.

A semi-dominant white with pink eyes, *Wh*, was found by Grobman and Charles (1947). The heterozygotes resemble phenotypically animals with blue dilution *dd*. They have ruby or red eyes. The eye size and fertility of *WhWh* mice are somewhat reduced.

B. *Mus bactrianus*—Asiatic mouse.

This species, which is fertile in crosses with *Mus musculus*, has long been domesticated in China and Japan. Evidence of homology of loci in the two species has been obtained for *A*, *B*, *D*, *P*, and *S*

by segregation in F_2 and in back-cross generations from a cross between the two species.

2. Genus *Rattus*—rats.

A. Norway Rat, *Rattus norvegicus* (also known in the literature as *Mus norvegicus*).

At the *A* locus, two alleles *A*, agouti, and *a*, non-agouti (black) have been described. This is in marked contrast with the six alleles found at this locus in the house mouse.

The brown (*b*) mutation was recorded by King (1932). It segregates clearly from its epistatic allele, *B*.

In the *C* locus, the c^a albino mutation is commonly known in domesticated rats, and has been observed in wild animals in England (Patterson, 1927). It is probable that a chinchilla C^{ch} (ruby-eyed) allele exists, although evidence for it does not seem to be as clear as in mice.

Blue dilution (*d*) has been independently recorded by Roberts (1929) and by Curtis and Dunning (1940). It appears to be homologous to the same mutant in mice, although the incidence of several genetic types of "dilution" in the latter makes complete identification difficult.

A gene fawn, *f*, reducing black and brown pigment, and genetically independent of *d* was reported by Castle and King (1947). This is another type of "dilution," but it is not clear whether it reduces yellow pigment as well as dark, since no crosses with animals with yellow were recorded.

Pink-eyed yellow, *p*, was one of the first mutants observed. It was found in a wild rat caught in England. It has a bright yellow coat and light pink eyes. It is recessive to full pigmentation, *P*.

Red-eyed yellow, *r*, was also discovered in a wild rat in England at about the same time. It also is recessive to full pigmentation, *R*. Both *p* and *r* are in the same chromosome and show about 20 per cent of crossing-over. They are also linked with albinism (C^a), grey lethal (*l*), and waltzing (*w*).

Four alleles occur at the piebald *S* locus in rats. Since white spotting in this species occurs usually in a symmetrical pattern called "hooded," *h*, the symbol *H* has been given to the locus in the literature. It would, however, seem more logical to use *S*, since the "Irish" pattern h^i (s^i) and the extreme white hooded h^w (s^w) are very closely parallel to alleles at the *S* locus in other types.

"Silvering" was discovered by King (1945) and was described by Castle (1953). It is not present in the juvenile coat, but appears at an age of 6 to 8 weeks and increases in conspicuousness until the animal is full grown. It is a recessive autosomal character in chromosome II and is linked with brown (*b*), Curly (*cv*), and shaggy (*Sh*).

B. *Rattus rattus*—Black Rat.

This rat occurs in three wild color types: white-bellied agouti, A^w; grey-bellied agouti, *A*; and non-agouti, *a*. An apparent mutation from *B* to *b*, brown, has also been observed in the agouti wild type. The albino, C^a, mutation has been recorded. Blue dilution, *d*, has been described.

The *E* gene has mutated both in the direction of "super-extension," E^D, and toward dark-eyed recessive yellow, *e*. This is interesting, for *Rattus rattus* provides the only well-authenticated mutations in this locus among the Muridae.

Feldman (1936) records a recessive "grizzled" mutation which has eventually from 5 to 75 per cent of white hairs scattered through the coat. The age at which the grizzling first appears is from 7 to 17 months, with an average of 14 months. It is not clear whether this mutation is similar to silvering in *Rattus norvegicus*, which occurs at a much younger age.

3. Genus *Cavia*—Guinea pig.

Although certain wild species, notably *Cavia rufescens* and *Cavia aperea*, have been studied experimentally, the great body of data is derived from genetic experiments on the domestic guinea pig, *Cavia porcellus*. There does not seem to be any evidence to justify a separate treatment of species in the present communication.

The *A* locus has mutated to produce white-bellied agouti, A^w, and non-agouti, *a*. Detlefsen (1914) has described among wild *Cavia rufescens* and in hybrids between this species and *Cavia porcellus* a very dark and sparsely ticked type of agouti. Although its genetic nature is not entirely clear, it would seem that a darkening gene or genes, like "umbrous" or "mahogany" in the house mouse, is a more plausible explanation than it would be to hypothesize another allele of *A* for the "dark" type.

The mutation of black *B* to brown *b* has long been recognized and classified as being apparently similar to the *b* gene of other mammals.

At the *C* locus, the remarkably skillful work of Wright (1917, et seq.) established a series of five alleles: *C*, full pigmentation; c^r, dark dilution; c^d, light dilution; c^r, red-eyed dilution; and c^a, albinism. The last named may in effect be C^{al}, or Himalayan albinism, since albinos carrying *E*

usually have the dark nose, ears, and extremities characteristic of that pattern.

At the *E* locus there are three alleles. *E* is full extension of dark pigment, e^{i} brindle or tortoise shell, and *e* red or yellow.

There is an interesting mutation, *f*, which dilutes red or yellow pigment, leaving black or brown unaffected. In this respect it resembles the "grizzled" gene, *gr*, in mice.

The pink-eyed *p* mutation, which reduces brown or black pigment but not red or yellow, has also been observed and studied in guinea pigs.

The piebald s^{p} mutation at the *S* locus gives rise to a wide-spread range of white spotting. No evidence of other established allelic centers of variation at this locus has been advanced. However, Pictet and Ferrero (1936) recorded a dominant ventral spot which may be due to an independent spotting gene.

Silvering, *si*, has probably been observed by Lambert (1935), who finds that the character begins to express itself at the second coat or later molts. It appears to be due to a recessive gene with plus and minus modifiers and affects all color varieties. Pictet and Ferrero (1936) may have observed a similar variation.

Roan (*Ro*), an incompletely dominant intermixture of white and pigmented hairs in black and in brown animals, was recorded by Ibsen and Gortzen (1951). The character is present at birth and remains unchanged with age. There are occasionally phenotypically normally pigmented animals which are genetically *Ro* heterozygotes.

Eaton (1943) found still another type of silvering restricted to brown (*bb*) animals. This is most prominent in young individuals and gradually disappears with increasing age. There is aberrancy in segregation ratios.

A very similar phenotypic character has been observed by the writer in cats (1952–53, unpub.). Unfortunately the strain in which it occurred was lost through distemper.

Ibsen and Gortzen (1951) have described a modifier of brown (*b*) and black (*B*) hairs which they term "whitish." They consider it incompletely dominant. Black animals tend to have decreased white with age, while browns show a similar decrease in females, but tend to retain it in males.

4. Genus *Lepus*—hares.

Species of this genus have not been successfully studied genetically in captivity.

Aldous (1939) quotes Merriam in his *Mammals of the Adirondacks* as describing two specimens of non-agouti (*aa*) black hares, *Lepus americanus*.

Ritchie (1926) reports an "albinistic" specimen from Scotland in *Lepus timidus*. The writer has not been able to obtain Ritchie's original paper, and it is uncertain therefore whether this is a mutation in the *C* or in the *S* locus.

Aldous (1939) describes a black hare, killed in Maine, which was apparently of the dominant black E^{D} type. Another of similar pigmentation was listed from Ontario by Merriam (see Aldous, 1939).

5. Genus *Oryctolagus*—rabbits.

Three alleles have been identified at the *A* locus. These are A^{w}, white-bellied agouti; a^{t}, black and tan; and *a*, non-agouti. A modifier of *A* has been listed as a single gene. This is *w*, wide-banded (more yellow) agouti. It is recessive to the ordinary normal type.

The mutation from black, *B*, to brown, *b*, is also well recognized.

At the *C* locus are six alleles, as follows: *C*, full pigmentation; C^{ch3}, C^{ch2}, and C^{ch1}, three grades of chinchilla with increasing degrees of paleness of color and reduction of yellow pigment; C^{H}, Himalayan albino; and c^{a}, complete albinism.

Blue dilution (*d*), which reduces all pigments, is a clear-cut recessive.

The *E* gene has mutated to super-extension E^{D} in one direction, and to the blotched red and black Japanese, e^{j}, and to yellow *e* in the other.

Spotting mutations have occurred. Because of the symmetry of certain phenotypic patterns, the designation "Dutch spotting," used by fanciers, has influenced the genetic nomenclature. It would seem preferable to consider these varieties of rabbits as due to mutation in the *S* locus. There are three alleles *S* (*D*), solid-colored coat; s^{i} (du^{d}), Irish spotting (dark Dutch); and s^{w} (du^{l}), extreme piebald (light Dutch).

In addition, there is a dominant spotting, known as "English," *En*. The homozygous *EnEn* type has some pigment around the eyes and on the ears, with perhaps a few scattered colored spots on the mid-dorsal line. The homozygous $s^{w}s^{w}$ type has pigment around the eyes and near the tail; the ears are white.

Another extreme spotting or pigment reduction type is the Vienna White, *v*, which is recessive and which has blue eyes, instead of pink eyes as in the albino.

At least one type of silvering, *si*, is found in

rabbits. This is recessive and may cover a considerable area of the coat, giving the animals a distinctly dilute appearance. Marchelewski (1929) describes a silvered type with solid-colored dark extremities. The genetic nature of this type is still in doubt.

6. Genus *Ondatra* (*Fiber*)—muskrat.

Mutation to the albino (c^a) type has been described several times (Dunn, 1921; Jones, 1923, Norton, 1944, 5 cases).

What appears to be a dominant black E^D has also been listed by Dunn (1921), Jones (1923), and Hatt (1930). Fawn coat color, probably representing the *e* mutation, has been described by Jones (1923).

Marked reduction of black pigment in both the coat and eye (*p*) has been recorded by Dunn (1921), while silvering similar to *si*, the type seen in mice, has been observed by Fletcher (1944).

7. Genus *Marmota*—woodchuck, marmot.

Albinos probably representing the c^a mutation have been recorded in the woodchuck, *Marmota monax*, by Dunn (1921) and by Cady (1945). They have also been observed by the writer in two cases, one in Maine and one in New Hampshire.

What may be the *b* mutation to produce a "dun" colored coat has been listed by Jones (1923) for the Russian marmot, *Marmota bobak*.

Melanism, probably due to E^D, has been recorded in four individuals of *Marmota flaviventris* in Wyoming by Fryxell (1928). The *e* mutation to fawn has been recorded by Jones (1923) in *Marmota bobak*.

The reduction of dark pigment with pink eye and with the yellow pigment unaffected has been recorded by Dunn (1921). This appears to be the *p* mutation.

8. Genus *Citellus*—ground squirrel.

A mutation probably at the *C* locus has been described. It occurs in *Citellus tridecimlineatus* (Fichter and Davis, 1942) and may well be a light chinchilla, c^{ch}, being described as having less concentrated dark pigment with "smoky-brown" guard hairs.

Clark and Jellison (1937) have described a "cream" mutant in *Citellus elegans* (Montana) which they consider to be closely parallel to the cream (*e*) mutation in the black rat. A mutation towards melanism, probably E^D, has been observed in *Citellus citellus* (Hungary) by Cerva (1931).

9. Genus *Tamias*—chipmunks.

The albino c^a mutation has been recorded in *Tamias striatus* by Dunn (1921) and in a pair of adult individuals by Zinn (1954).

A black mutant, either E^D or *a*, has also been listed by Dunn (1921).

10. Genus *Sciurus*—tree squirrels.

Albino individuals, probably c^a (Jones, 1923), and pink-eyed, in two species, *Sciurus hudsonicus* and *Sciurus carolinensis* (Dunn, 1921), have been described.

Black mutants, probably E^D, have also been recorded in these two species (Dunn, 1921), and by Hatt (1930) in *Sciurus carolinensis*. The black mutation occurs regularly as one of three "color phases" of *Sciurus niger niger*. Another phase is described as "buff" but, since many intermediates occur between it and the characteristic "gray" phase, its unigenic nature is doubtful. Manville (1955) described a black individual of *Sciurus carolinensis* with a shorter than normal tail, the tip of which is white. Whether this represents simply an E^D mutant, with possibly a traumatic origin of the white tail tip, or whether it is a true pattern factor, is not clear.

A number of piebald or spotted individuals have been observed: Dunn (1921) in *Sciurus finlaysoni*; Jones (1923) in *Sciurus carolinensis*; and Serebrennikov (1931) in the Siberian squirrel. These appear to be the s^p or *s* mutation in some form.

11. Genus *Thomomys*—Western pocket gophers.

Burnett (1925) has described an interesting mutant in *Thomomys talpoides*, "blue black with an ocherous belly," and with a clear line of demarcation between the areas. This sounds as though the a^t pattern has been produced.

Another mutant (Burnett, 1925) is deep cream, lighter underneath, and is probably the *e* type.

12. Genus *Geomys*—Eastern pocket gophers.

In *Geomys breviceps*, McCarley (1951) has described a number of variations. What appears to be the silvering or grizzling mutation, *si*, has been observed in a form which is "over-all" white, with few dark hairs, as well as in a more heavily pigmented form, in which the white hairs are mostly concentrated in the cephalic region. These conditions are seen in other rodents with the *si* gene.

Mutations which may involve the *S* locus or the *bl* locus include the appearance of a "single" head spot, a "double" head spot, and a white ventral spot.

Somewhat extensive study of spotting in the house mouse suggests that these three types may well be expressions of a single gene, such as "blaze,"

bl, or else variations of the "Irish" spotting pattern.

13. Genus *Perognathus*—pocket mouse.

Blair (1940) has reported melanotic (probably E^p) specimens of *Perognathus fasciatus* from North Dakota.

14. Genus *Dipodomys*—kangaroo rat.

A mutation to albinism, c^a, has been described by von Bloeker (1930) in *Dipodomys heermanni*. A very pale variety (c^a ?) is reported by Blair (1940).

15. Genus *Castor*—beaver.

Albino c^a mutants have been recorded by Jones (1923) and by Mertens (1929). Both authors have observed the mutants in *Castor canadensis*. Jones (1923) records all black individuals, which probably represent the E^p mutation. She also reports the occurrence of "fawn" animals, probably *e* in type.

In this species Jones (1923) also lists silvering, probably due to the *si* mutation, and white spotting, which is of the piebald s^p type.

16. Genus *Peromyscus*—white-footed mouse.

This genus has been under experimental investigation for a considerable period of years, and in many laboratories. As a result, a relatively large number of coat color mutants has been reported, and some progress in their genetic analysis has been made. No attempt to separate the studies by species will be made in this paper. The genus will be treated as a unit.

In the *A* (agouti) locus, Clark (1938b) has described a recessive mutation which produces a variable number of hairs with yellow terminal, or subterminal, bands in the pectoral region. Since the typical *Peromyscus* is white-bellied agouti, A^w, it is probable that the new type is an allele in the direction of the gray or yellow belly characteristic of *Mus musculus*.

Apgar (1930) and Dice (1933) describe "yellow" and "buff" "mutants" from the ordinary wild type of *Peromyscus maniculatus*. From Apgar's description of the variants that he observed, they would appear to be a modified type of A^w, the genetic nature of which is not known. Dice mentions that the "buff" mutant is dominant to gray, but certainly indicates that it may *not* be similar to the dominant A^y gene of the house mouse. Until extensive and carefully controlled breeding experiments are carried out the genetic analysis of these variations at the *A* locus will be inconclusive.

Mutation from *B* (black) to *b* (brown) has been described by Huestis and Barto (1934). The *b* mutant is a simple recessive.

At the *C* locus, it seems probable that the c^{ch} mutation has produced the coat color described by Clark (1938b) as "silver agouti." The true albino c^a type has often been observed and behaves as a typical recessive (Dunn, 1921); Feldman, 1937; Barto, 1941). Clark (1936) demonstrated linkage between albinism, c^a, and pink-eye (probably *p*) with about 15.8 per cent of crossing over; and Huestis (1946) showed linkage between albinism c^a and flexed tail (*fl* ?).

What appears to be the dilute (*d*) mutation has also been observed (Feldman, 1937 "pallid"; Clark, 1938b; Barto, 1941).

At the *E* locus, although no dominant mutation such as E^p has been observed, the recessive yellow variety (*e*) has been described and studied (Huestis and Barto, 1932). Dunn (1921) also mentions the existence of a "yellow" type.

The pink-eyed (*p*) mutation, which is linked with albinism, c^a, is well known and was studied by Clark (1938b). "Ivory," described by Huestis (1938), is whitish brown in the juvenile pelage, and as an adult is dull white with red eyes, darker than those of the c^a albino. "Ivory" is due to a simple recessive gene which is not an allele of c^a, *b*, or *d*. There is a possibility that it may be an allele of *p*, and for want of further knowledge it is therefore described as such at this time. The independence of ivory from albinism has been shown by Clark (1938b) and by Barto (1941).

Silvering in *Peromyscus* is apparently of two main types. The first was described by Sumner (1928) as "grizzled." Although its expression was very variable and its segregation at times not exactly in conformity with expectation (Clark, 1938b), it was always "dominant." Interestingly, it did not reveal itself in the first pelage, and often became apparent only after six months. There is here an interesting parallel with the action of the "greying" or "grizzling" gene (*g*) in dogs.

The second type called "silvering" (Huestis and Barto, 1934) is recessive and is probably the same as the gene *si* in the house mouse.

Several types of spotting have been described. At least one of them (Feldman, 1937) is dominant, although there are no data to show whether it parallels the effects of the *W* series in the house mouse. Feldman (1936b) also reports a dominant "white face," and a number of animals with "white stars," or "belts." Various combinations of crosses produced much variability, as might be expected. Recently, McIntosh (1956) has described a new type of recessive spotting called "whiteside." The ventral and lateral hairs are completely unpig-

mented. The homozygous form shows a delayed formation of the yellow band of the agouti hair pattern. The mice become deaf at about three weeks of age and some of them later develop the "whirling" habit. One of the by-products, however, was some animals which were "totally white with black eyes." This would result if a gene such as *W*, which has been identified in the house mouse, was also present in *Peromyscus*.

17. Genus *Cricetus*—hamsters.

Petzsch (1940) reported albinism (c^a) recessive to fully pigmented types. Melanistic (all black) mutants have been frequently observed. Jacobi (1927) writes that since 1771 a perfectly black hamster has been found in certain places in Europe and Asia, and that it is probably a mendelian mutation. Petzsch (1940) reports that the melanistic type is dominant to wild color. This is confirmed by Gershenson and Polevoi (1941). It would seem, therefore, that the black mutant is E^D, rather than *a*, in nature.

Petzsch also mentions that "flavism" is recessive to wild color, and Robinson (1955) clearly describes a "cream" mutant which appears to be *e* in type.

In the same paper, Robinson lists a "ruby-eyed" mutant in which the coat color is "weakened." His description suggests that it is probably the *p* mutation.

A piebald mutation recessive to self color was described by Foote (1949) and was further studied by Orsini (1952). The expression of the piebald pattern, which lacks rather strikingly the clear-cut edges of white areas, indicates a difference between it and the s^p gene of other rodents. This probability is further strengthened by certain pleiotropic effects of the gene in hamsters. Piebaldness is accompanied by increased embryonic mortality, decrease in body size, and urinogenital aplasia affecting the kidney, ureter, uterus, and vaginal orifice.

18. Genus *Sigmodon*—cotton rats.

Partial replacement of black pigment by "brown" is recorded by Sherman (1951). It is probable that the variation is a modification of the agouti pattern, which may or may not have a genic mutation basis of origin. The same author lists an albino mutant which seems to be of the orthodox c^a type.

Danforth (1949) describes a dominant spotting which produces a white or nearly white coat color. The mutation has been recorded twice, once in New York, and once in California. In one case, the mutation appears to have occurred in the germ cell, in the other after some development of the ovum. Genetically, the mutation is dominant and is lethal when homozygous. It thus resembles closely the behavior of certain alleles of the *W* locus in the house mouse.

19. Genus *Synaptomys*—lemmings.

The only available record of a mutation in this genus is that to albinism, c^a (Manville, 1955), in the bog lemming, *Synaptomys cooperi*. A single male individual was reported.

20. Genus *Evotomys*—red-backed mouse.

In this genus, one record of mutation known to the writer is that to E^D. Allen (1927) reports one individual in a litter of two which had all red pigment replaced by black. The other locus at which mutation is reported is the *S* locus, where Dunn (1921) records piebald in this same species.

21. Genus *Microtus* (*Pitymys*)—meadow mouse, field mouse, vole.

In listing the recorded mutations, no effort will be made to separate these species, in presenting the evidence which is still fragmentary and largely based on observation, rather than on breeding experiments.

What appears to be the A^y yellow mutation has been observed by Owen and Shackelford (1942) in two individuals of *Microtus pennsylvanicus* and in one *Pitymys pinetorum*.

Mutation to *b*, brown, was described by Clark (1938a) in a single male found dead in a trap. An earlier record by Snyder (1930) of a "cinnamon" individual may also be the *b* mutation.

At the *C* locus the complete albino variety C^a has been recorded by Warren (1929) in *Microtus nannus*; by Fisher (1942) in *Microtus californicus*; and by Owen and Shackelford (1942, three individuals), Dunn (1921), and Hatt (1930) in *Microtus pennsylvanicus*. What may be the C^H (Himalayan rabbit or guinea pig) mutation was described in a female by Clark (1938a). The extreme dilute c^e type also seems to occur (Snyder, 1930, one case; Owen and Shackelford, 1942, three cases).

"Blue" dilution, *d*, appears to be present in one individual of *Microtus pennsylvanicus* and one *Pitymys pinetorum* reported by Owen and Shackelford (1942).

There have been several cases of "yellow" mutants which appear to be of the *e* type. The one best supported on the basis of breeding experiments is reported by Clark (1938a). Hatt (1930) lists a yellow mutant, and Orr (1941) records three

yellows believed to be in the same litter. It is uncertain, however, whether these are e or A^y in genetic constitution. Snyder (1930) also reported an animal which was "dark buff," with gray under fur, and which had normally pigmented eyes. What appears to be the pink-eyed p mutation was recorded by Dunn (1921) and by Owen and Shackelford (1942) in two of four animals. It is possible that two of these four individuals were produced by mutations other than p, such as "ruby eye," or some similar gene.

At the *S* locus, Corkrum (1953) has observed "aberrant" white areas in five of 900 specimens of *Microtus ochrogaster*, the prairie vole. It is possible that they represent s^p, a piebald mutation. An extensive white spotting, probably extreme white piebald s^w, was described by Clark (1938a). As in a case reported by Dunn (1921), there was a tendency towards a "hooded" condition in this individual, which is an interesting resemblance to the common expression of spotting in rats, *Rattus norvegicus*. One individual with blue eyes, resembling the "Vienna white rabbit," was recorded by Owen and Shackelford, as were two predominantly white mice that may well have been of the s^w type.

What appear to be black-eyed whites, or nearly "whites," which may represent mutations of the *W* type, have been observed by Owen and Shackelford in two individuals.

In comparing genes in different genera or species in Table 1, it is necessary to have some means of expressing different degrees of probability that homology exists. As has already been mentioned, certainty in this respect can only be attained when a fertile cross between species shows that identifiable loci are opposite to one another in the same chromosome pair. This situation seldom occurs. When there is a strong probability of homology, a cross + will be used, and where a lesser but still significant degree of probability exists, a question mark in combination or alone will indicate the estimated probability of homology.

Since only in the house mouse and guinea pig do analyses of the morphogenetic and biochemical levels of gene activity exist, the grouping of genes on the chart will be based on phenotypic comparison and on experimental genetic resemblances.

Where the house mouse alone appears to include a mutation or where another single species may show a number of phenotypically somewhat similar mutations which are inadequately analyzed, these mutations have been omitted from the condensed tabulation.

Carnivores

1. Genus *Canis*—dogs, wolves.

A. *Canis domesticus*, the dog.

The *A* locus in the dog may contain any one of several alleles. The top member of the series is A^s, by which the other agouti alleles are completely or almost entirely masked. Next in the series is a^w—wild color—found in a few breeds and reproducing what is essentially a coat color like the wolf. This is seen in perhaps its most typical phase in Norwegian Elkhounds or in gray German Shepherd dogs. The third allele is a^y, which in its homozygous condition gives a tan or light sable coat color. At times the term "fawn" has been used to describe the expression of a^y in certain breeds. The lowest member of the allelic series is "tan-points,' a^t, a term which the author (1957) has used to include black or liver animals with tan or light brindle muzzle, feet, underside of tail, and perianal region. While different heterozygous combinations show varying degrees of dominance between and of expression of these alleles, their existence and segregation appears to be established.

In many breeds of dog the *B* gene has mutated to *b*. Certain varieties, such as Chesapeake Bay Retrievers and Weimaraners are all of them *bb* in genetic constitution. There may be variation in depth of pigment, but the mutation itself is well recognized.

The *C* locus has certainly two and probably three mutant alleles, with a fourth one reported but now apparently lost. The c^{ch}, or chinchilla, mutant reducing the depth of yellow pigment and leaving brown or black little affected—at least in the short-haired breeds—is frequently encountered. Miniature Schnauzers and Norwegian Elkhounds are good examples of the expression of the $c^{ch}c^{ch}$ genotype. Extreme dilution, c^d, or at least an allele reducing pigment below the c^{ch} level, may also be present in such breeds as Pugs, Cocker Spaniels, and/or Poodles. Its action on yellow pigment is extensive and pups born with "white," which later develop a cream or pale yellow tint or streaks in certain areas are often recorded. The fourth and bottom member of the allelic series is complete albinism, c^a, which by definition should produce all white animals with pink eyes. It has been reported but is extremely rare.

TABLE 1

Coat color genes of rodents

GENUS, SPECIES	*A* LOCUS						MODIFIERS OF *A*				*B* LOCUS				*C* LOCUS					*D* LOCUS			*E* LOCUS				*P* LOCUS			*S* LOCUS				*Si* LOCUS		*W* LOCUS				
	A^y	A^w	A	a^t	a	a^e	DARKENERS			LIGHTENER	B^{lt}	B	b^s	b	C	c^{ch}	c^a	c^H	c^a	D	d	d^1	E^D	E	$\frac{e^t}{e^1}$	e	P	p	p^r	S	s^i	s^p	s^w	Si	si	W	W^v	W^a	W^j	w
							u	*mh*	*da*	w																														
Mus musculus (House mouse)	+	+	+	+	+	+	+	+	+	−	+	+	+	+	+	+	+	?	+	+	+	−	+	−	?	+	+	+	+	+?	+	+?	+	+	+	+	+	+
Mus bactrianus (Asiatic mouse)	−	+	+	−	+	−	−	−	−	−	−	+	−	−	+	−	−	−	−	+	−	−	+	−	−	+	?	+	+	?	+	−	+	−	−	−	−	−	+
Rattus norvegicus (Norway rat)	−	−	+	−	+	−	−	−	−	−	−	+	−	+	+	?	−	−	+	+	+	−	−	+	−	−	+	+	−	+	+	+	+	+	−	−	−	−	+
Rattus rattus (Black rat)	−	+	+	−	+	−	−	−	−	−	−	+	−	+	+	−	−	−	+	+	+	−	+	+	−	+	+	−	−	+	?	−	−	+	+?	−	−	−	+
Cavia porcellus (Guinea pig)	−	+	+	−	+	−	−	−	?	−	−	+	−	+	+	+	?	+	?	+	−	−	−	+	+	+	+	+	−	+	?	+	?	+	+?	−	−	−	−	+
Lepus (*Hares*)	−	−	+	−	+	−	−	−	−	−	−	+	−	−	+	−	−	−	?	+	−	−	+	+	−	−	+	−	−	+	−	−	−	+	−	−	−	−	+
Oryctolagus (Rabbits)	−	+	−	+	+	−	−	−	−	?	−	+	−	+	+	+	−	+	+	+	−	−	+	+	+	+	+	+	−	+	+	+	+	+	+	−	?	−	−	+
Ondatra (*Fiber*) (Muskrat)	−	−	+	−	?	−	−	−	−	−	−	+	−	−	+	−	−	−	+	+	−	−	+	+	−	+	+	+	−	+	−	−	−	+	?	−	−	−	−	+
Marmota (Woodchuck, marmot)	−	−	+	−	?	−	−	−	−	−	−	+	−	?	+	−	−	−	+	+	−	−	+	+	−	+	+	+	−	+	−	−	−	+	−	−	−	−	−	+
Citellus (Ground squirrels)	−	−	+	−	?	−	−	−	−	−	−	+	−	−	+	+?	−	−	−	+	−	−	+	+	−	+	+	−	−	+	−	−	−	+	−	−	−	−	−	+
Tamias (Chipmunk)	−	−	+	−	?	−	−	−	−	−	−	+	−	−	+	−	−	−	+	+	−	−	−	?	+	−	+	−	−	+	−	−	−	+	−	−	−	−	−	+
Sciurus (Tree squirrels)	−	−	+	−	?	−	−	−	−	?	−	+	−	−	+	+	−	−	+	+	−	−	+	+	−	−	+	−	−	+	−	+	−	+	−	−	−	−	−	+
Thomomys (Western pocket gopher)	−	−	+	+	−	−	−	−	−	−	−	+	−	−	+	−	−	−	−	+	−	−	−	+	−	+	+	−	−	+	−	−	−	+	−	−	−	−	−	+
Geomys (Eastern pocket gopher)	−	−	+	−	−	−	−	−	−	−	−	+	−	−	+	−	−	−	−	+	−	−	−	+	−	−	+	−	−	+	?	−	−	+	+	−	−	−	−	+
Perognathus (Pocket mice)	−	−	+	−	−	−	−	−	−	−	−	+	−	−	+	−	−	−	−	+	−	−	+	+	−	−	+	−	−	+	−	−	−	+	−	−	−	−	−	+
Dipodomys (Kangaroo rats)	−	−	+	−	−	−	−	−	−	−	−	+	−	−	+	−	−	+	?	+	+	−	−	+	−	−	+	−	−	+	−	−	−	+	−	−	−	−	−	+
Castor (Beavers)	−	−	+	−	?	−	−	−	−	−	−	+	−	−	+	−	−	−	+	+	−	−	+	+	−	−	+	−	−	+	−	+	−	+	+	−	−	−	−	+
Peromyscus (White-footed mice)	−	+	?	−	−	−	−	−	−	?	−	+	−	+	+	+	−	−	+	+	+	−	−	+	−	−	+	+	+	?	+	+	+?	−	+	+	?	?	−	−	+
Cricetus (Hamsters)	−	+	?	−	?	−	−	−	−	−	−	+	−	−	+	−	−	−	+	+	−	−	+	+	−	−	+	+	?	−	−	?	−	+	−	−	−	−	−	+
Sigmodon (Cotton rats)	−	+	−	−	−	−	?	?	?	?		+	−	−	+	−	−	−	+	+	−	−	−	+	−	−	+	−	−	+	−	−	−	+	−	+	?	−	−	+
Synaptomys (Lemmings)	−	−	+	−	−	−	−	−	−	−	−	+	−	−	+	−	−	−	+	+	−	−	−	+	−	−	+	−	−	+	−	−	−	+	−	−	−	−	−	+
Evotomys(Redbacked mice)	−	−	+	−	?	−	−	−	−	−	−	+	−	−	+	−	−	−	−	+	−	−	+	+	−	−	+	−	−	+	−	+	−	+	−	−	−	−	−	+
Microtus (Field mice—voles)	+?	−	+	−	−	−	−	−	−	−	−	+	−	+	+	−	+	?	+	+	+	−	−	+	−	+	+	+	−	+	−	+	+	+	+	−	?	−	−	+

The author has never seen this type of mutant, and the total of thousands of pups recorded in many breeds by cooperative breeders does not contain a report of this mutation. [The writer has circulated among thousands of dog breeders blanks for recording coat colors in whole litters of most of the breeds recognized by the American Kennel Club. These data form a part of the material in a book, *The Inheritance of Coat Color in Dogs*. (Comstock Publishing Co., Ithaca, N. Y. 1957.)]

The mutation from intense pigment *D* to blue dilution, *d*, has been observed in several breeds and characterizes all animals of one—namely, the Weimaraners—which are *bb dd* in genetic constitution. The "blue" may be relatively light and flat in color, as in Great Danes, or it may be deeper and richer, becoming almost "gunmetal," as in Doberman Pinschers or Chihuahuas. It is a clear recessive which segregates cleanly.

The *E* locus in dogs presents some interesting and rather involved problems. The ordinary varieties of black and brown coat color are A^aA^aEE in constitution. A mutant of *E*, hypostatic to it, is e^{br}, brindle, seen commonly in Great Danes, Bulldogs, and Greyhounds. The pattern consists of alternating dark and light stripes, usually very distinct from one another. When the brindle pattern is combined with the agouti pattern in a^w or a^y (sable) animals, and with long or wiry hair, as in most Scottish Terriers, it is more difficult to distinguish. Even in these cases, however, if one removes or clips short the long guard hairs, the undercoat shows the brindle pattern clear and distinct. There are many grades of the brindle pattern, some being almost black and others predominantly fawn or tan, with very narrow dark stripes. Between these two extremes is a whole range of forms differing in extent and depth of pigment.

The lowest member of the *E* series of alleles is *e*. In the homozygous *ee* animal, the coat is deep red, as in the Irish Setter, and any of various intermediate shades of red or yellow, as in the Cocker Spaniel, or even cream-colored as in some Poodles.

One mutant departs from *E* in an epistatic direction. It is a "pattern-producing" gene, E^M, which produces localized dark pigment in a^ya^y tan or fawn varieties. Its ordinary expression is a heavy black "mask," and darkening of the legs. It is frequently seen in fawn Great Danes and is the usual pigment distribution in fawn Pugs. It forms a black mask in brindle, e^{br}, or wild-type varieties. It covers the tan muzzle in tan-pointed animals. In all-black animals it produces *no* visible effect, for they are already black muzzled. In *ee* types it produces no effect, for there is no ability to form pigment for the E^M gene to extend.

The *G* gene in dogs produces a gradual greying or dilution of the coat which finally becomes and remains a steel blue, or blue-grey. The *Gg* puppies are born black, as are usually the *GG* type.

This gradual dominant expression of the action of the *G* gene proceeds at different rates and may even reach slightly different coat-colors as end-products in different breeds. In Kerry Blue Terriers, where its expression is not complicated by other paling or diluting genes, its behavior is relatively simple and easy of detection. In Dandy Dinmont Terriers, where hair length and the probable action of the c^{ch} paling gene are modifying influences, the part which *G* plays is more obscure. Finally in Poodles, hair length, the c^{ch} and *d* genes, heterozygosis of *Bb* types, and an apparently non-genetic aging effect which produces greying, all combine with the action of *G* to produce a thoroughly confusing complex of genotypes and phenotypes.

The merle gene *M*, which is another dominant, is found in Dachshunds, Collies, Shetland Sheepdogs, and in some other breeds. In its heterozygous form, *Mm*, it produces a blotched coat color of irregular adjoining and contrasting areas of dark (black or liver) and of blue-grey or light drab-grey pigment. There also usually appear on the coats of *Mm* individuals white spots of various sizes and locations. One or both eyes may show heterochromia iridis or even such a decrease in iris pigment that a blue or "white" eye results. In the Collies and Shelties, the homozygous *MM* type is all white or nearly so. Deafness and eye defects, sometimes extending to extreme microphthalmia and blindness, are frequent. In the Dachshund, there is usually more pigment in *Mm* and *MM* genotypes than there is in the other two breeds. Deafness is not so common. On the other hand, there are records of dark-eyed white Dachshunds which may well represent the extreme expression of the *MM* genotype.

Evidence of a gene *P* as one element responsible for contributing to full development of dark (black or liver) pigment is provided by the recording of pale blue-grey animals with pink eyes (p). Although Pearson and Usher (1929), who reported them, include them in a monograph on albinism, it is probable that a locus entirely distinct from the *C* locus is involved in the mutation that produced

them. Outside of the Pekingese breed in which they were reported, and this one source in the literature, no other recorded incidence of this mutation is available.

The ordinary types of white spotting in dogs seem to depend upon different combinations of four alleles at the *S* locus. The top-ranking member, *S*, ordinarily produces in *SS* genotypes a completely pigmented coat with no white areas. In most breeds, however, modifying genes are able to produce a few white hairs on the forehead or a small white spot on the chest, belly, or toes. The heterozygotes between *S* and each of the other three alleles, s^i, "Irish" spotting, s^p, piebald, or s^w, extreme white piebald, often show incomplete dominance of *S*. In such cases, the white on the muzzle, feet, belly, and chest may be increased in amount, and the tail-tip and a "collar" of varying extent may be added to the unpigmented areas.

The "Irish" allele, s^i, resembles phenotypically these heterozygotes just described. Its most typical expression, largely if not entirely uncomplicated by the presence of the other S alleles, is seen in Basenjis.

The piebald allele, s^p, may include at one extreme phenotypes indistinguishable from the s^is^i "Irish" type of spotting, and at the other extreme animals which are entirely white, except for a small patch of pigment around the ear and/or near the tail. Beagles or particolored Cocker Spaniels are good examples of breeds showing the extremes of expression of s^p, and all grades in between.

The lowest member of the allelic series is s^w, extreme white piebald. Bull Terriers, Sealyham Terriers, and Great Pyrenees are examples of s^ws^w breeds. Rarely does an animal of these breeds have as much as 10 per cent of its total coat area pigmented. It is evident that in any mixed population of spotted animals, careful individual matings are necessary before a genetic analysis of genotypes can be made.

Another very interesting gene in dogs which expresses itself only on unpigmented areas of the coat is *T*, which produces "ticking," or stippling with small spots of various sizes and shapes. Either the first areas in which ticking appears or the last from which it disappears, if its distribution is limited, are those which are tan in color in the a^t (tan point) type of the *A* series of alleles. Whether or not this limited distribution represents an allele of *T* is not known, but the problem is worth investigation. Ticking may be "light" with few or widely scattered spots, or "heavy" with many, closely adjacent spots. It seems probable that the extreme of heavy ticking is seen in the roan varieties such as the German Shorthaired Pointer, where spots may actually blend and the background color becomes a smoky, cloudy light grey or brown, instead of white, against which the darker spots are contrasted. The time of appearance of the ticking varies in different breeds, but it is rarely, if ever, present at birth.

It is interesting to note that the Dalmatian, or Coach Dog, which has, at times, been considered a special and different type of spotting, actually seems to be s^ws^wTT in genetic constitution (Little, 1957).

B. *Wild Canidae.*

Black specimens of the dingo, *Canis dingo*, the common wolf, *Canis lupus*, and the American wolf, *Canis occidentalis*, have been reported by Jones (1923). They are probably A^s mutants from the a^w or a^y gene. A case of possible mutation from *B* to *b* in the dingo has been listed by the same author.

"Brindle," which if accurately used means a mutant of the *E* gene to e^{br}, is reported in the dingo. Fawn or almost red, which could mean either an *e* mutation or a change from a^w to a^y has been found in *Canis lupus* and *Canis occidentalis*.

Crosses reported between the dog and wolf by various authors, notably Iljin (1941) and Kohts (1948), have not greatly clarified the genetic make-up of the latter species. Kohts, however, believes that there is more genetic variation, chiefly from a^w to A^s and a^y in the common wolf, *Canis lupus*, than is generally admitted. He lists black, black and tan (tan-points), and "ochreous" among wolf-dog hybrids. If the black and tan reported by him is actually genetically of that type, a^t, it would seem to be likely that the *e* mutation to yellow had also occurred in the wild species. Dice (1942) also records "black and tan" in F_1 hybrids between the coyote, *Canis latrans*, and the dog. In view of these observations, it seems very likely that the "black and tan" hybrids are really a^ya^t genotypes with heavy darkening modifiers. In crosses between domestic dogs, this genotype is often so "dark" as to be phenotypically indistinguishable from certain phases of the black-and-tan (tan-points) pattern.

2. Genera *Ursus* and *Euarctos*—Bear.

Jones (1923) reports three possible gene mutants

in the black bear, *Ursus americanus*. The normal type is apparently black and tan (tan-points), a^{tp}.

One mutant appears to be clearly "Irish" spotting (s^i) in which white chest or paw spots are recorded. The other is listed by her as "silvering." Without more data, it is impossible to determine whether this variation is an expression of the type of "greying" characteristic of the action of gene *G*, or whether it is a manifestation of the gene *si*, found in rodents. The probability that it is the former is increased by her report of "grizzling," as a third form of coat-color variation.

A form of coat-color probably representing the "*d*" mutation is recorded by Jones (1923). It is described as "blue." Since the next most probable alternative in diluting the black color would be a mutation in the *C* and *B* loci, occurring coincidentally, mutation in the *D* locus appears to be the more likely explanation.

The Cinnamon Bear is probably due to a mutation from *B* to *b*. The proportion of the *b* to the *B* phenotypes varies in different geographic areas, as would be expected if it was a mutant color phase of the Black Bear.

Jones (1923) also cites a "white" mutation in the Cinnamon Bear. It is interesting to note that *Eurarctos kermodei*, the Kermode Bear, is ordinarily pure white, except for "buffy to ochraceous wash on head and dorsal line" (Anthony, 1928). It is considered by some to be a form of *Ursus americanus*. In view of this fact, it is probable that the "white" reported by Jones and the "white" of the Kermode Bear may be due to "extreme dilution," c^e, in the *C* series of alleles.

Another mutant, "light yellow," has been recorded by Jones (1923). It would seem that this resembles the *e* mutant in other forms, such as the domestic dog. The other possibility, namely, that it might be due to the *p* mutation, is less likely. In other mammals which are *bb pp*, the coat color is a dull, flat, and rather dark yellow, rather than "light."

Since the Grizzly Bear, *Ursus horribilis*, commonly shows in its coat a mixture of dark and light hairs, and also has given an even lighter than normal amount of pigment, the existence of a coat color roughly analogous to "silvering" in rodents is known in the species.

3. Genus *Procyon*—Raccoon.

This genus has a well-defined basic color pattern of light and dark areas with especially clearly defined black mask and tail rings. It is probable that this pattern is never "lost," no matter whether or not its expression is impaired. The normal coat-color also exhibits very clearly the "agouti" type ticking of individual hairs. It is probable that it is analogous to the a^w "wild color" gene in dogs, or the a^w "tabby" gene in cats.

Among subspecies, there is variation in the number and breadth of tail rings and in the shape or extent of the black mask. It seems likely that such variation is due to some extrachromosomal factor, or factors, with or without the action of modifying genes. There is no evidence of any clear-cut single gene difference between such subspecific color variations.

There is, however, evidence of three mutations which appear to be based on single genes.

Black or almost black forms have been reported by Jones (1923), and by Whitney (1931). These are probably due to an E^D mutation similar to dominant black in rabbits, or to an A^s mutation of the type seen in dogs. As yet there is no genetic basis for distinguishing between the two.

Pink-eyed yellow—This type, in which the tail bands are darker than the rest of the coat, has been recorded by Whitney (1931) and has been observed by Mr. Acil Underwood and myself (unpub.) at about the same time. The mutant is recessive to normal coat-color and is probably similar to one of the *p* genes recorded in rodents.

Albino—pink-eyed white has also been observed by Underwood and Little (unpub.) and has been preserved in several museums. There seems to be little doubt that this is the typical c^a albino mutation which occurs in many rodents and some other carnivores.

4. Genus *Mustela*—mink.

The genetic analysis of mutants in mink is made difficult by a number of events. First, the breeders have given different names to the same mutation occurring in the wild type. Second, they have, at times, given the same name to different mutants. Third, they have given descriptive names to a number of genotypes resulting from interaction of various genes, some dominant to the wild type and some recessive to it. Fourth, there has not been sufficient central genetic research to enable us to form a clear picture in all cases as to whether mutants observed in different ranches are identical.

Castle and Moore (1937) stated that the wild mink "has no very obvious coat pattern." They conclude, however, that it represents a modified type of agouti, in which selection for darker-

coated individuals has resulted in reducing or masking the visibility of lighter bands or areas in the individual hairs. Jones (1923) has described black or nearly black specimens, and it is probable that these are actually A^a solid colored mutants.

Clear evidence for the occurrence of the mutation from *B*, black pigment, to *b*, liver-brown, is given by Smith, Whitaker, Davis, and Noble (1941) by Shackelford (1941), and by Gildow (1944). The brown mutant is variously described as "pastel," or "blond." It is an autosomal recessive.

In the *C* series there may be several alleles, although sufficient controlled genetic crosses are not as yet reported to establish them firmly. Shackelford (1949) gives data on a mutant called "green-eyed pastel" which in certain lights shows red or ruby eye color. It has a "light" colored coat, and may well be the c^{ch} or "chinchilla" step in the albino series. It is entirely independent of the *b* pastel variety. In the same paper, a mutant called "Goofus" is described as having a very light coat color with dark extremities like a Siamese cat. It is probably c^H, the "Himalayan" type of allele. In 1954, Shackelford and Moore spoke of the "average" albino mink as being of the formula c^Hc^H. It could be, therefore, that the "Goofus" variety was a new allele between c^{ch} and c^H, or it could be merely the darker expression of the c^H gene. Jones (1923) also listed the true albino or c^a member of the series.

There have been two genetically distinct recessive mutations causing dilution of the coat color in mink. One of these, which has been variously described as "platinum," or "silverblue" (Castle and Moore, 1937); Smith et al., 1941; Shackelford, 1941; Genetti, 1944; Gildow, 1944), is apparently a mutation from *D* to *d*. Shackelford (1948) has observed that in the individual hair the pigment granules show the "clumping" which is a characteristic effect of the *d* gene in many species.

The second type of dilution does not differ greatly phenotypically from the first, but in crosses with it the wild type of intense pigmentation is reconstructed, thus showing genetic independence of the two types. The second type is called "Aleutian" (Shackelford, 1949).

Castle and Moore (1937) have listed still another recessive dilution known as Gunmetal blue (*g*) which they record as being distinct genetically from the other mutants.

There also appears to be a partially dominant black-eyed white type called "Hedlund white" (Shackelford and Moore, 1954). The heterozygous form has white on the belly and occasionally has a "blaze" on the forehead. The white animals are reported to be "probably" deaf. This type of mutant may possibly occur in other wild species but has not been recorded in other domesticated carnivores.

The dominant coat-color mutations in mink are relatively numerous and are interesting. One of the early mutants recorded has been variously described as "choke," "royal silver," "silver," and "Koh-i-nur" (Castle and Moore, 1937; Castle, 1946b; Smith et al., 1941; Shackelford, 1949). It has been given the symbol S^s. The heterozygote $S^s/+$ has a white chest and belly, but is otherwise dark agouti or black. The homozygous S^sS^s is black-eyed white, with small colored areas between the ears and at the base of the tail.

A third allele epistatic to S^s and $+$ is probable. It was given the name of "Blackout" by Castle and Moore (1937). Shackelford (1949) gives it the symbol *S* and cites the results of matings which seem to support the triple allelic theory. The homozygous *SS* type has a black patch covering the top of the head and irregular black patches interspersed with white hairs on the sides. The SS^s heterozygote also has a large black head-patch, a black dorsal streak, and black and white hairs interspersed on the sides. The $S/+$ heterozygote has a white muzzle and sides of the neck. The belly, feet, and lower area of the sides are also white. Very superficially, certain of the phenotypes are not unlike "English" spotting in rabbits at the heavily pigmented end of the scale of expression of that pattern.

A second type of dominant paling, to which Castle and Moore gave the symbol *F*, was described by them (1937). It is independent of the *S* series mentioned above and may possibly bear some resemblance to the merle, *M*, gene in dogs. It is probable that the homozygous *FF* type is lethal.

A third type of mutant named "Baldy" has, according to Castle and Moore (1937), a white head and "generally paler coat." It is not in the *S* series. When in combination with *bb*, it frequently produces nervous twisting of the head and at times convulsions (Shackelford and Cole, 1947). At times this color variety is also called "Colmira." Little has yet been recorded on the detailed genetic analysis of "Baldy."

A final dominant "spotting" gene has been

called "Ebony" and when in combination with *bb*, "Palamino."

Although there may be much more extensive analyses of these dominant mutations than those with which the author is familiar, it would seem that centralized experiments on their interrelationship would be most desirable.

Spotted types with white areas on a dark background have also been described in terms which suggest that they are due to mutations of, or modifiers of, the *S* gene. These could, in contrast to the varieties discussed earlier in this section, be recessive in nature.

Melanistic types of the wild (modified agouti *A* type), probably representing mutations to A^a and described by Jones (1923) as "almost black," have been observed in *Martes americana*, the American marten, *Martes pennanti*, the fisher, and in the Russian sable, *Martes zibellina*. There is, of course, the possibility that they are due to a "super-extension" of black by an E^D mutation, as in rodents, but the former explanation seems more probable.

What is likely to be the *b* mutation has also been listed by Jones for *Martes pennanti*, "light brown or fawn," and for *Martes zibellina* in the same terms.

In the *C* locus, Jones describes forms of *Martes pennanti* as occurring in "light or pale colors," which may well be c^{ch} or c^a. Certain of the white or nearly white forms of *M. americana*, *pennanti*, and *zibellina*, and of the stone marten, *Martes foina*, may be extreme dilute individuals. They are also considered again in the later paragraph on the *S* locus. The baum marten, *Martes martes* and *Martes americana*, have both appeared in a "blue" or "drab" variety (Jones, 1923). They are probably *dd* mutants.

Silvering or grizzling have also been reported by Jones in *Martes americana* and *Martes zibellina*. Ponomarev (1938) states that in the latter species grizzling is "partially dominant." This makes it similar in general action to the *G* gene in dogs.

Spotted types are relatively common. Ponomarev (1938) mentions white-headed *Martes zibellina* on the Isle of Feklistov as apparently due to a single recessive gene. White-bellied, white-footed specimens observed in museums suggest the "Irish" s^i spotting mutation. The "almost white" individuals may, if only a small amount of dark pigment is present in clear spots, be the "extreme white piebald" s^w mutation seen in dogs, cats, and many rodents.

6. *Genera Lutra*—Otter; and *Enhydra*—Sea Otter.

Jones (1923) recorded the albino c^a mutation in the otter, *Lutra canadensis*. She also listed a slate-colored specimen which in all probability represents a dilute, *d*, mutant. Light and dark brown types are recorded in *Enhydra*, the sea otter, by Jones (1923). It is probable that these are mutations from black (*B*) to brown (*b*).

7. Genus *Gulo*—Wolverine.

Almost black specimens of the wolverine were reported by Jones (1923). They are probably mutants from the modified agouti pattern which characterizes the wild type.

The mutation from *B* to liver-brown, *b*, is also recorded, according to Jones.

A completely albinistic form c^a has also been observed according to the same author.

8. Genus *Mephitis*—Skunk.

The skunk is non-agouti in coat color. Its black and white pattern marks it as unique in contrast to most of the wild North American mammals. It is probable that this is a mutation comparable to *a* in rodents, and it has been so listed. Jones (1923) reported the occurrence of a "drab or brown" specimen, which is probably the *b* mutation. There is also a record of a complete albino c^a mutation (Haven, 1927).

The variation in the black and white pattern itself is extensive. It resembles, at least superficially, the range which one finds in the hooded pattern in rats. In the latter case, there is evidence of three alleles, one of which is centered around the heavily pigmented types known as "Irish" spotting. A second allele covers the intermediate degrees of the hooded pattern. A third reduces the amount of pigment to small spots on the head.

Whether the skunk has any such multiple allelic series is uncertain. There are no available data on controlled breeding experiments. It is, however, true that the pattern in the skunk is highly variable, and that almost black individuals occur at one end of the scale and that almost white animals, at the other, have frequently been observed.

9. Genus *Vulpes*—Fox.

In *Vulpes fulva*, the red fox, the close attention of commercial fur breeders to quantitative variations in the expression of various coat-colors in the different genotypes has introduced certain factors which complicate, to some extent, the genetic analysis of the phenotypes.

Certain facts, however, seem to be clear. The normal red fox has a distinctive color pattern, with very little dark pigment on the body. The nose and feet are darker. The total effect is not unlike the combination $a^v a^v E^M E^M$ in dogs, which show a restricted expression of the E^M gene.

Silver-black foxes would appear to be due to a mutational change from a^v to A^s. Their genetic formula would therefore be $A^s A^s E^M E^M$. The cross-fox, which is the hybrid form between the red and silver-black, shows incomplete dominance of A^s over a^v. Butler (1945) and Cross (1941), as well as many practical breeders, would agree that a single pair of alleles is involved and that matings of cross foxes inter se produce a ratio of 1 silver-black: 2 cross: 1 red.

The different degrees of "silvering" in the $A^s A^s E^M E^M$ silver-blacks are undoubtedly due to modifiers, as selective breeding experiments in commercial ranches have shown.

Similarly, evidence given by Butler (1945) on variations in color phases of the red fox in Canada indicates that more than one modifying gene may influence the amount of dark pigment in $A^s a^v E^M E^M$ or in $a^v a^v E^M E^M$ genotypes. Oksala (1954), studying this problem in Canada, Alaska, Siberia, Russia, and Fenno-Scandinavia, also recognizes at least two, and possibly three, modifying genes.

There are other recognized mutants which may affect either red, cross, or silver-black foxes, which are only of limited commercial value, and therefore have received intensive study only in the silver-blue variety.

The first of these, called "pearl," or "pearl platinum," appears to be a simple recessive to silver-black. Bowness (1944) notes that while the ground color of pearl animals is blue-grey, the amount of "silvering" is the same as that in silver-blacks.

The probability that pearl is due to the *d* mutation is increased by the work of Shackelford (1948), who showed that the individual hairs of that color variety revealed "clumping" of pigment granules. This is a characteristic of *dd* animals in dogs, cats, and rodents.

An independent mutation produces "platinum," W^P, and white-marked W types. According to Johansson (1947), whose symbols are used, these two types, along with silver-black, W^+, form a triple allelic series. Although Johansson describes the *Ww* type as "white faced," the term "white marked," used previously by Gildow (1944) and Gunn (1945), is preferred by the writer. It is interesting to note that the "merle" *M* gene in dogs increases the amount of white spotting in the coat, and has many of the attributes of the *W* gene in foxes.

The independence of this mutation from the *d* locus is indicated by the distribution of pigment granules in the individual hair (Shackelford, 1948) and is clearly demonstrated in a cross reported by Cole (1945b). This cross was as follows:

$W^P w\ DD$ platinum × *ww dd* pearl

F_1 = 1 $W^P w\ Dd$ platinum
1 *ww Dd* silver-black

Backcross:

$W^P w\ Dd$ platinum × *ww dd* pearl

1 $W^P w\ Dd$ = platinum
1 $W^P w\ dd$ = pearl platinum
1 *ww Dd* = silver-black
1 *ww dd* = pearl

There is also evidence that the genotypes $W^P W^P$, $W^P W$, and *WW* are lethal (Johansson, 1947). The first named type, $W^P W^P$, dies "at, or soon after, birth."

Additional evidence is provided by the earlier work of Gunn (1945), who found that whereas the cross of *Ww* (white-marked) × *ww* (silver-black) gives "white-marked" and silver-blacks in equal numbers, the cross *Ww*, white-marked, inter se gives 67.4 per cent *Ww*, white-marked, and 32.6 per cent silver-black. The 2:1 ratio indicates that the homozygous *WW* genotype is lethal.

The cross of standard platinum $W^P w$ × white-marked *Ww* gives a ratio of 1 standard platinum $W^P w$ to 1 white-marked *Ww* to 1 silver-black *ww* —showing that the genotype $W^P W$ is also lethal.

Silvering in the red *ww* genotype has been recorded (Jones, 1923). It appears to be due to the action of the *si* gene.

A variation which turns the normal rich red coat to "light fawn" has been reported by Jones (1923). It is, of course, impossible to identify the exact genetic nature of this type, but it seems probable that it is a variation at the *C* locus in the direction of chinchilla c^{ch}.

Finally, Jones also reported that "white coat color" with "black marks" in the coat has been recorded in the fox. From this very brief description it is not possible to distinguish between the extreme white piebald s^w variation, or an "Hima-

layan," or "extreme dilution" phase of the *C* locus. It seems certain, however, that the description does *not* fit that of c^a, true albinism. In *Vulpes velox*, the kit fox, the normal form is buffy yellow with some white-tipped and some black-tipped hairs. There is a black spot on the sides of the snout and near the base of the tail. The underparts are whitish.

Jones (1923) has described a "fawn" variation in this species, and since this term is often used to denote a flattening or dulling of color it may well be that this is a *d* (dilute) mutant.

10. Genus *Alopex*—Arctic or Blue Fox.

Alopex lagopus—Arctic fox; Blue fox. This species is a uniform fawn in summer and turns to a clear white in winter. It is probable that it is *dd* in genotype.

Blue fox is a color mutant somewhat analogous to the silver-black mutant of *Vulpes fulva*. Since the blue fox appears to be *dd* in genotype, the likelihood of its parental species color-type being also *dd* is increased. The blue type, however, does not become white in winter. This is an interesting fact which merits investigation.

Jones has reported "silvering" (probably s^i) and brown (probably *b*) mutants. She has also listed a "white spotted" form which is very likely to be "Irish" spotting (s^i). An "almost white" type mentioned by her is of uncertain genetic make-up; because it is not stated whether it is almost white due to symmetrical general decrease in pigment (c^e) or has only a small patch or two of the normal blue coat color on an otherwise pure white background (s^w).

11. Genus *Felis*—Cats.

A. *Felis domesticus*, domestic cat.

There are at least three alleles at the *A* locus in cats. The top member of the series is the "wild" type, *A*, which is similar to the common tabby or "tiger" cat. It has agouti hairs distributed through the coat, but also fine black stripes on the sides and a longitudinal black stripe along the mid-dorsal line. The tail is often banded with circular rings of black. There is at least one hypostatic form of the tabby pattern with blotches and whorls of broader black bands on the side and with a heavier mid-dorsal band than that of the wild type. This allele, a^{tq}, resembles a pattern known as "torquatus." The third allelic member is non-agouti, *a*. It is seen in the non-ticked varieties, such as black or blue (Maltese) (Whiting, 1918; Castle, 1930a).

It is important to note at this point that many *aa* non-agouti kittens show in their first coat a "ghost" pattern of stripes similar to the *A* or a^{tq} varieties. This disappears in the course of successive coats as the animal develops. It is probable, therefore, that all cats have a basic pattern, even though its visibility may be masked or concealed. Reference will again be made to this fact when locus *E* is considered.

At the *C* locus, there are four and perhaps five alleles. The top member of the series is *C*, the fully pigmented type. Distinct from this and affecting both black and yellow pigment is "silver," which by analogy with other forms appears to be the "chinchilla," or c^{ch} mutant. The greater visible reduction of the yellow pigment as compared with black is characteristic of that gene. Next in order of hypostasis is "Burmese," c^B. Thompson, Cobb, Keeler, and Dmytryk (1943) definitely established the position of this allele as hypostatic to c^{ch} and epistatic to Siamese c^H. The development of pigment in c^{ch}, c^B, and c^H animals is definitely affected by temperature, as it is in the c^H mutation in guinea pigs.

The mutation from intense pigment, *D*, to blue or Maltese dilution, *d*, has been frequently recorded. Segregation of the two types is simple and clear-cut.

The *E* locus in cats is interesting in that the gene is borne in the X chromosome. *EE* cats are black or tabby; *ee* animals are orange, yellow, or cream; while *Ee* animals are "tortoise shell," with various proportions of dark and yellow areas. The common types of cats in the shorthaired, fully pigmented series are as follows:

AEX AEX	= tabby ♀
*AEX A*Θ	= tabby ♂
aEX aEX	= black ♀
*aEX a*Θ	= black ♂
AeX AeX	= yellow ♀
*AeX A*Θ	= yellow ♂
AEX AeX	= tortoise shell tabby ♀
aEX aeX	= tortoise shell ♀

There is a large literature concerning the origin and genetic nature of the very few tortoise-shell males which have been observed. Since they represent a most unusual and perhaps a unique case, they will not be considered further in this comparative study.

What seems to be a super-extension of black E^M is found in Siamese and undoubtedly in Burmese cats. It is epistatic to tabby, but segregates

from, and behaves towards, *e* just as does *E*, ordinary extension.

Grizzled kittens which were definitely a dark silver grey at birth, and which later became fully pigmented blacks or tabbies, have been obtained from certain matings observed by the writer (unpub.). Unfortunately, the strain in which they occurred died out before their genetic nature could be analyzed. On the basis of these incomplete data, it seems probable that they were due to a gene somewhat similar to the *G* gene in dogs.

Various grades of piebald spotting have been recorded as probable mutations in the *S* locus. The self or completely pigmented *S* type is undoubtedly subject to the effect of modifiers which produce a chest spot or a few white hairs on the forehead. The "Irish" type of spotting, s^i, with white throat, chest, and feet, and with a ventral spot is commonly seen. There then follows a wide range of piebald forms which are commonly asymmetrically spotted except on the head and feet, where the white areas tend to be symmetrical. These probably represent $s^p s^p$ genotypes. There is often incomplete dominance of *S* or s^i over s^p, thus creating some difficulty in distinguishing certain genotypes phenotypically.

Extreme white piebalds, s^w, with pigment only in small areas at the anterior and posterior somatic limits, are also observed.

In addition to these spotted types, there is a dominant white, *W*. The heterozygotes with *w* sometimes have a small colored spot between the ears. This spot is usually less intensely pigmented than the coat of the particular genotype would be in the absence of *W*. *WW* whites (and possibly *Ww* animals) may be either yellow-eyed or blue-eyed, or rarely with one eye of each color. The blue-eyed whites are commonly, and the yellow-eyed whites occasionally, completely deaf.

B. *Wild Felidae.*

Since there is a number of scattered observations on several genera and species, they will be grouped according to the general type of variation or mutation in order to save space.

Modification of the characteristic wild coat-color by melanistic extension of black pigment has been reported for the tiger, *Felis tigris*, and for the jaguar, *Felis onca*, by Jones (1923). She also, together with Eates (1943) and Thom (1944) has recorded a black mutant of the leopard, *Felis pardus*. In most of these cases, it would appear that a mutation to A^a or to E^M was involved. The relative probabilities of the two types of mutant depend somewhat upon whether the ordinary coat patterns of the three species represent a modification of the *E* gene or of the *A* gene. There is at present no way in which a definite decision on this matter can be made.

Another pattern change in the ocelot, *Felis pardalis*, and the leopard, *Felis pardus*, has been listed by Jones (1923). In the modified form, stripes "like a tabby" replace the ordinary rosette or blotched pattern. This situation seems to closely parallel the varieties of patterns seen in the domestic cat. It probably represents an *A* locus change. Whether a mutation from *B* to *b* has occurred is uncertain, for "dark brown" tigers, or a light brown European lynx (*Lynx lynx*), recorded by Jones (1923), may be either of this origin or due to a change in the *C* locus.

Pale-colored varieties, which may mean modification of the *C* gene, have also been observed. It is difficult to evaluate these in terms of alleles, but the following brief descriptions will give some idea of the range of variation.

Van Ingen and Van Ingen (1941) report a leopard with a "pale tan background and darker rosettes," and a female tiger with "white ventral regions, pale tan background and fine stripes of dark tan with three stripes of black at the end of the tail." Both of these animals may well represent the c^{ch} or "chinchilla" mutation.

The same authors also recorded a "white tiger with chocolate stripes"; and Fooks (1941) described a pale-colored leopard "with blue eyes." These variations could be c^a or extreme dilution. In this category also may fall a cheetah, *Acinonyx jubatus*, which is "almost white" but with a few "light brown spots," and a bay lynx, *Lynx rufus*, "almost white," listed by Jones (1923).

The change from intense *D* pigmentation to the dilute *d* mutant is the probable origin of blue or light blue forms of the Canada lynx (*Lynx canadensis*) and the bay lynx (*Lynx rufus*) in the variations listed by Jones (1923).

Yellow or "red" mutants are also known (Jones 1923). If analogy with the domestic cat holds good, these would be changes in the *E* locus. Three forms reported by Jones are: Canada lynx, "fawn or yellow"; bay lynx, red and paler; and the caracul, *Felis caracul*, "yellow."

Grizzled or silvered coat color, which might mean a type of silvering, *si*, or of true paling, like dom-

TABLE 2

Coat color genes of carnivores

GENUS, SPECIES	A LOCUS					B LOCUS		C LOCUS					D LOCUS		E LOCUS					G LOCUS		M LOCUS*		P LOCUS		S LOCUS				Si LOCUS	
	A^a	a^w	a^y	a^t	a	B	b	C	c^{ch}	c^e	c^H	c^a	D	d	$\frac{E^M}{E^D}$	E	e^{br}	e	G	g	M	m	P	p	S	s^i	s^p	s^w	Si	si
Canis domesticus (Dog)	+	+	+	+	−	;	+	+	+	+	−	+?	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−
Canidae wild (Wolf, dingo)	+?	+	+	+?	−	+	+	+	+	?	−	−	+	−	+	+	+?	+?	−	+	−	+	+	−	+	+	−	?	+	−
Ursus, Eurarctos (Bear)	−	+	−	+	?	+	+	+	−	+?	−	−	+	+	−	+	−	+?	+?	+	−	+	+		+	+	−	−	+	+
Procyon (Raccoon)	+?	+	−	−	−	+	−	+	?	−	−	+	+	−	+?	+	−	−	−	+	−	+	+	+	+	?	−	−	+	−
Mustela (Mink)	+	+?	−	−	−	+	+	+	+?	−	+?	+	+	+	?	+	−	−	−	+	+	+	+	−	+	+	?	−	+	?
Martes (Marten, sable)	+?	+	−	−	−	+	+	+	?	+?	−	+	+	+	?	+	−	−	+	+	−	+	+	−	+	+	?	?	+	?
Lutra (Otter)	−	+?	−	−	−	+	+	+	−	−	−	+	+	+	−	+	−	−	−	+	−	+	+	−	+	−	−	−	+	−
Enhydra (Sea Otter)																														
Gulo (Wolverine)	+?	+?	−	−	−	+	+	+	−	−	−	+	+	−	?	+	−	−	−	+	−	+	+	−	+	−	−	−	+	−
Mephitis (Skunk)	−	−	−	−	+	+	+	+	−	−	−	+	+		−	+	−	−	−	+	−	+	+	−	−	+	+	+	+	−
Vulpes (red fox, kit fox)	+	+	+	−	−	+	−	+	+?	−	+?	−	+	+?	?	+	−	−	+?	+	+?	+	+	−	+	+	−	?	+	+
Alopex (Blue fox)	−	−	+	−	+	+	+	+	−	?	−	−	−	+	−	+	−	−	+?	+	−	+	+	−	+	+	−	?	+	+
Felis domesticus (Cat)	?	+	−	−	+	+	−	+	+	+	+	−	+	+	+	+	−	+	?	+	+?	+	+	−	+	+	+	+	+	?
Felidae Wild (Lion, tiger, leopard, etc.)	+?	+	+	−	−	+	?	+	+	+?	−	−	+	+	+?	+	−	+?	?	+	−	+	+	−	+	+	−	−	+	?

* In the comparative gene table for carnivores the *M* locus has been used as the recording point for certain mutants which may well be more nearly homologous with mutants in the *W* locus of rodents. More extensive genetic studies must be made before their detailed qualities can be determined.

inant *G* in dogs, has been noted in the caracul and the tiger (Jones, 1923).

It is probable that mutations in the *S* locus, producing "Irish" spotting, s^i, are fairly common. A clear case in the lion, *Felis leo*, has been reported by Schneider (1930). A normal male, apparently Ss^i in formula, was crossed with a white-footed female in the Zoological Garden at Leipzig. Two normal and two white-footed cubs were obtained. A full sister (normal) by the same male gave one normal and one white-footed cub.

In Table 2 is given a comparison of gene mutations in various carnivores. The domestic dog is used as the foundation type, although it will be noted that the non-agouti *a* mutation at the *A* locus and the *si* mutation producing recessive silvering have not been definitely established in that species.

COMPARISON OF GENES BY LOCI

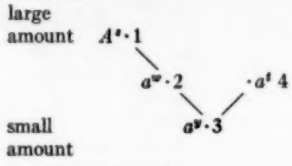
A Locus

One of the most widespread and interesting of the loci which produces coat-color patterns is the *A* or agouti locus. The agouti pattern represents not only a broad regional distribution of differently pigmented hairs, but also a delicately controlled and highly variable alternation of enzyme activity in pigment formation in the individual hairs. Genetic factors are known to modify the expression of the gene, and there are good reasons for believing that metabolic and environmental factors may also influence the extent and duration of action of the black-brown enzymes.

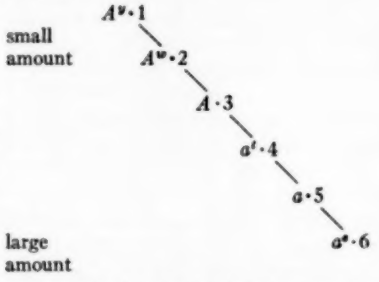
As a locus, it also has some interesting multiple allelic series. The effects is the heterozygous state and of modifying genes are interesting and may be briefly described for two of the most completely analyzed species.

In dogs, the top member of the allelic series is solid colored A^s; next is a relatively little-studied agouti coat, known as "wild color," a^w. A^sa^w animals have fewer "ticked" hairs than a^wa^w. It is also probable that darkening modifiers can produce a^wa^w animals which are definitely melanistic. The next member of the series is a^y, tan or sable. When darkening modifiers are present, dark hairs may appear in considerable numbers. When they do, they are located in areas which are dark in tan-point, a^t, animals of the next allelic step. Similarly, a^ta^t animals with lightening modifiers approach phenotypically the a^ya^y animals which have darkening modifiers. Tan-point animals with darkening modifiers are often very difficult to distinguish from self (solid-colored) A^s individuals, since so little tan remains visible.

In regard to the amount of dark pigment expressed phenotypically, the series is an interesting and irregular one.



In mice, the series runs from A^y, yellow (lethal); A^w, white-bellied agouti; *A*, agouti; a^t, tan-points (black and tan); *a*, non-agouti; to a^e, extreme non-agouti.



The series in mice is, therefore, continuous and unbroken in the direction of an increase in *B* and *b* enzyme activity correlated with hypostasis.

In general, among the wild Rodentia there are many minor modifications of the agouti pattern, but very few recorded major mutations. One of the latter, however, appears to be the a^t, or tan-point (black and tan) mutation in *Thomomys*, the western pocket gopher. There is also suggestive, but as yet inconclusive, evidence that the mutation A^y to dominant yellow may have occurred in *Microtus*.

In carnivores, mutation to tan a^y is apparently fairly widespread among the Canidae and Felidae. It also is found in the genus *Vulpes*. The a^t, or tan-point, mutation has been recorded in *Vulpes* and wild Canidae. It also is characteristic of the black bear, *Ursus americanus*.

B Locus

This locus is perhaps one of the most consistent and orthodox in genetic behavior. There are ordi-

narily two alleles, *B*, which produces black pigment, and *b*, which produces brown. In only one species, *Mus musculus*, are there other alleles. It might follow that if very extensive breeding experiments were carried out, more than two alleles would be found in other forms. At present, however, the mutation from *B* to *b* has been recorded in mice, rats (both *Rattus norvegicus* and *Rattus rattus*), guinea pigs, rabbits, *Peromyscus*, *Microtus*, and possibly in *Marmota*. In carnivores, dogs, wolves, bears, the blue fox (*Alopex*), the skunk, marten, wolverine, sea otter, and mink, have all had brown mutants. It is interesting that the Felidae, both domestic and wild, have failed to produce this mutant, so far as records available to the writer are concerned.

It would appear that the basic process of black-brown pigment formation is genetically very similar, if not identical, within and between the two great groups of mammals studied.

C Locus

The two extreme alleles at this locus, *C* or full pigmentation, and c^a or complete albinism, are widespread.

In rodents, with the possible exception of certain species of tree squirrels and of Muridae, the *C* gene appears to be present and effective. In carnivores, the wild Canidae (western types of wolves) are probably pale (c^{ch}, chinchilla) in pigmentation, but all other wild types seem to be *C* or fully pigmented.

It is quite natural that complete albinos (c^a) are easily recognized, even in the wild state, and are often collected for museum specimens when seen. In rodents, this mutation has been recorded in fifteen, and possibly sixteen, of the twenty-one genera studied. The ground squirrel, *Citellus*, pocket gophers, *Thomomys* and *Geomys*, the red-backed mouse, *Evotomys*, and the pocket mouse, *Perognathus*, are the only exceptions, and none of these genera has been very extensively studied.

In carnivores, the distribution of the c^a mutation is most interesting and is possibly significant. It has been recorded in *Procyon* (raccoon), *Mephitis* (skunk), *Martes* (marten), *Gulo* (wolverine), *Lutra* (otter), and *Mustela* (mink). There is no available record of its certain appearance in the Canidae or Felidae, either domestic or wild. Neither has it been described in the foxes, *Vulpes*, *Alopex*, or *Urocyon*, or in the Ursidae (bears).

Although at very infrequent intervals a dog breeder may report the birth of a "pink-eyed white" puppy, the absence of known adults of this color suggests that the recorded puppy may have been a pink-eyed or ruby-eyed dilute which as it matured produced some pigment in the coat and was therefore either the *p* type of mutation or something very similar.

When one considers the vast number of dogs and cats that man has observed and reared, and the extent to which foxes have been hunted and shot, the absence of the complete albino is a striking phenomenon to which it would seem some biological significance could be attached.

Between *C* and c^a, one finds a series of "paling" genes, usually in allelic relationship. Because of incomplete dominance, modifying factors, and other complicating variables, it is difficult to draw homologies or perhaps even analogies. It seems, however, that in all cases of the processes of pigment reduction at the *C* locus, there is an orderly and progressive paling through the "chinchilla," c^{ch}, or ruby-eyed phase to that of extreme dilution, c^a. Somewhere along the series, a pigment reduction pattern known as "Himalayan" may occur. This is found commonly in rabbits and guinea pigs, and possibly, though extremely rarely, in the house mouse and *Microtus*. In none of these forms has it been possible to test its genetic relationship to extreme dilution, c^a. In carnivores, the pattern of the Siamese cat is ordinarily classed as being due to the c^H mutation. There are also records of probable cases of the "Himalayan" pattern in the fox (*Vulpes*) and the mink (*Mustela*).

It is perhaps worthy of note that whereas in rabbits and guinea pigs, *ee* (yellow) animals with c^Hc^H Himalayan pattern are *pure white*, yellow cats with the Siamese pattern have well-pigmented extremities, nose, ears, legs, and tail, and also normally show a certain amount of diffuse pigmentation over the whole body with increasing age. This may mean that the Siamese pattern of cats is not in the same category as the Himalayan pattern of rodents.

D Locus

At the *D* locus the standard situation has been one of a two-allele relationship. *D*, intense pigmentation, has been the epistatic member and *d*, called "blue," or "maltese," dilution the hypostatic. In the house mouse a third allele, d^l, hypostatic to *d* and lethal, has been described. There has, however, been no record of a similar allele in other species.

In the house mouse there are several genes, at independent loci, all of which have a "diluting" effect. Some of these cause the "clumping" of pigment observed in "blue" (*d*) dilution; others do not, and still others have not yet been studied in respect to the distribution of melanin granules within the hair.

What appears to be the *d* mutation has been observed and studied genetically and histologically in the Norway rat, the black rat, rabbits, and *Peromyscus*. It has been recorded, but not studied genetically, in *Microtus*.

Among carnivores, a dilution gene with the same type of behavior has been recorded and studied in the dog, cat, and mink. This coat color has also been described in the bear, otter, marten, and kit fox, *Vulpes velox*. It may well be the common type of coat in the blue fox, *Alopex*.

Unless data from breeding experiments are available, it is impossible to determine the degree of homology between the various genes causing "dilution," and the *d* gene as such. There is an additional complication. The various *C* alleles involved in producing increasing paleness in coat color are often difficult to distinguish from the *d* effect, unless a comparison with known *dd* types or microscopic studies of pigment distribution are made. There are, however, enough well-established cases of the *d* effect to demonstrate its occurrence in both rodents and carnivores.

E Locus

Absence of evidence of mutation in the *E* locus in the house mouse, Asiatic mouse, and Norway rat is a matter of interest, especially as what seems to be the recessive yellow, *e*, mutation has been recorded in the black rat, *Rattus rattus*, as well as in most other species of rodents which have been subjected to experimental breeding or which have been captured in large numbers. It is also a common mutation in carnivores.

The super-extension E^D or E^M mutation is difficult to distinguish phenotypically in captured wild specimens from the non-agouti *aa* types. In the Muridae, however, the black forms of *Mus musculus*, *Rattus norvegicus*, and *Rattus rattus* are most of them genetically of the *aa* type.

It is also of interest that although the "brindled," "mottled," "tortoise shell," and "dappled" mutations of mice affect the distribution of black (dark) and yellow (light) pigment and are due to a gene or genes on the X chromosome, they seem to be entirely different from the black-yellow sex-linked relationship in cats. In fact, the gene or genes in mice really behave in expression more like the autosomal dominant spotting genes of the *W*, S^p, or *Va* loci.

In cats, the heterozygotes of black (*E*) and yellow (*e*) are called tortoise shell and present a blotched or mottled coat with areas of black or yellow which are irregular in both size and distribution. In animals with piebald spotting s^p, the contrasting spotted areas tend to be larger and to have more distinct boundaries than in *SS* colored individuals. To some extent this is also true of the non-sex-linked allele e^t in guinea pigs and e^j in rabbits, each of which produces a "tortoise shell" pattern.

It is probable that the relationship between the "extension-restriction" series and the "self-piebald" series is related to a basic factor or factors in morphogenesis. The fact that there is evidence in favor of this in both rodents and carnivores is interesting.

The mutation to E^D, or E^M, a sort of "super-extension" effect, has been frequently and widely observed. Among the Muridae, the black rat is the only species in which it has been recorded. It is also lacking in *Peromyscus*, *Microtus*, and in guinea pigs. In rabbits, it is clearly established and well analyzed genetically. Field notes have listed individuals which appear to be E^D in the hare, muskrat, woodchuck, ground squirrel, chipmunk, tree squirrel, beaver, hamster, red-backed mouse, and pocket mouse. The distribution of this mutation by genera is therefore interesting.

While there is no way except by breeding tests to distinguish certainly between black or "almost black" animals produced by an E^D or an *a* mutation, there are certain clues which may be helpful. One of these is the observed incompleteness of dominance of E^D over *E* or *e* in agouti or yellow rabbits. Occasional agouti hairs in an otherwise black coat are therefore evidence in favor of E^D. Such agouti hairs are absent from blacks which are genetically *aa*.

Among the carnivores, it has been shown that the dog and domestic cat have this gene. Wild Canidae and Felidae also produce what seem to be "dominant" black or melanistic types. In addition, there is a possibility that certain melanistic individuals of fox, marten, wolverine, and mink are of this genetic type.

Reference has been made to the interesting absence of evidence for the *e* (recessive yellow) mutation in the house mouse and Norway rat, and to its presence in the black rat (*Rattus rattus*). As a mutation, *e* is widely distributed among rodents. It is well established genetically in guinea pigs, rabbits, *Peromyscus*, and hamsters. The type of coat color which *ee* produces has also been recorded in the muskrat, woodchuck, ground squirrel (*Citellus*), pocket gopher (*Thomomys*), beaver, and *Microtus*. In carnivores, it is recognized in the cat, dog, and probably in wild Canidae.

The dog at present provides the only opportunity to study the interaction of two genetically independent types of restriction of black or brown pigment producing tan or yellow. The complementary synthesis of F_1 animals with dark black or brown coat color has been demonstrated. Frequently there is a bronze or coppery undertone which suggests that $A^a a^y$ *Ee* individuals may show some phenotypic effects of the a^y and *e* genes.

When $A^a a^y$ *Ee* animals are crossed inter se there has been observed, in preliminary tabulations, a deficiency of tan or yellow animals in F_2; a phenotypic resemblance of F_2 tans or yellows to either the $a^y a^y$ *EE* or $A^a A^a$ *ee* types; and no strikingly new phenotypes which might be the new $A^a a^y$ *ee*, $a^y a^y$ *Ee*, or $a^y a^y$ *ee* combinations. It is possible, therefore, that these combinations are lethal or sublethal. A similar opportunity to study the interrelations of two types of reds or yellows in rodents would be of the greatest value in producing valuable information on the morphogenesis and physiological genetics of melanin pigments.

G Locus

Genes that produce "grizzling" or "silvering" present another confusing problem. There is often an effect of aging which increases the number of white hairs which are interspersed with pigmented ones. In addition to this aging effect, which may be non-genetic, there are instances of opposite aging effects which are, in all probability, attributes of the silvering or grizzling genes themselves. Thus, in dogs the gene *G* for greying acts increasingly with age.

The gene for silvering in the Norway rat has no visible effect until the animal is from 6 to 8 weeks old. It then increases in effect until the animal is full grown. There is an even later type of silvering in the black rat which first appears at from 7 to 17 months. Much the same situation occurs in guinea pigs. Here, however, in addition to the recessive type there is an incompletely dominant roaning gene which is present at birth and remains unchanged with age. Silvering in rabbits appears to be recessive, with at times a pattern effect which produces dark extremities. Silvering of unknown genetic type has been recorded in *Geomys*, the eastern pocket gopher, and in the beaver and the muskrat. In *Peromyscus*, a dominant type of "grizzling" with very variable expression and delayed appearance has been recorded. So, also the recessive type of silvering has been described. The existence of two distinct and independent types of genetic influences, each of which can produce "grizzled," "roan," or "silvered" coat color has thus been well established. These are shown in the tables as *G* and *si*. In carnivores, "grizzling" has been recorded in bears, martens, red fox, and arctic fox. There are no genetic data by which its type can be analyzed.

The climax of interrelated effects of these genes which produce "grey," "silver," or "blue grey" coat color in what would otherwise be black animals is reached in Poodle dogs. Here "chinchilla" or other paling effects of mutations at the *C* locus may combine with a dominant grizzling or greying gene *G* and with an apparently non-genetic tendency of certain black animals to become increasingly grey with age. These pigment changes become further complicated if they occur on a background of "blue" dilution, *dd*, or possibly *Dd*. The establishment of a genetic formula for individuals, therefore, becomes an exceedingly difficult matter.

P Locus

The *p* mutation, which greatly reduces the amount of black or brown pigment in the coat and eye, leaving the former some shade of yellow or tan and the latter pink, has been described in the house mouse, the Norway rat, guinea pig, muskrat, woodchuck, *Peromyscus*, and *Microtus*. In all these types, the phenotypic effects seem to be similar and, where genetic studies have been made, the clear-cut recessive nature of the gene's action has been established.

There is distinct probability that the *p* mutation occurred in *Mus bactrianus*, the Asiatic mouse, independently from its appearance in

Mus musculus. If this is the case, the *p* genes in the two species are identically located in the chromosome, as are the *A*, *B*, *C*, *D*, *S*, and *W* genes, since segretation in F_2 and back-cross hybrids between the species is orthodox. It is also interesting to note that in both *Mus musculus* and *Rattus norvegicus*, as well as in *Peromyscus maniculatus*, there is linkage between the *C* and *P* loci.

There are records of what seem to be the *p* mutation in Pekingese dogs and an observed case of its occurrence in the raccoon. It is however absent in other carnivores.

S Locus

It is generally recognized that mutations producing white spotting are among the most difficult to classify and analyze. Modifying genes may influence markedly the phenotypic expression of major spotting genes or may create spotting in spite of major genes for non-spotted coat color.

In spite of this fact, the so-called "Irish" spotting first described by Doncaster (1905) in rats, and considered to be due to the s^i allele at the *S* locus, is broadly distributed, and in rats, rabbits, and dogs segregates clearly enough to provide good evidence of its genetic nature.

In wild species of rodents and carnivores, it is uncertain whether white ventral spots, white feet, and white tail tip, which are characteristic of the "Irish" pattern, are really due to the s^i gene, or represent failure of the *S* gene under influence of "minus" modifiers, to cover the whole body surface. It is known, in domestic species, that the expression of the *S* gene can be so affected.

Individuals with the "Irish" pattern have been recorded in *Mus musculus*, *Mus bactrianus*, *Rattus rattus*, muskrats, beaver, eastern pocket gophers, *Peromyscus*, and *Microtus*. Among the carnivores, the dogs, wild Canidae, the cat, wild Felidae, the red fox, arctic fox, marten, mink, and bear have provided examples of the pattern.

In the skunk, *Mephitis*, it is probable that some of the more heavily pigmented individuals are genetically s^i. Other animals in the intermediate spotting range may well be s^p, piebald, which is an allele hypostatic to s^i. At the other end of the series, representing the extreme reduction of pigmented areas, may be the type s^w—extreme piebald individuals. Since, however, in dogs (Beagles) the s^ps^p genotype can apparently vary from phenotypically Irish to the extreme piebald pattern, the genetic situation in the skunk will remain to some degree uncertain until breeding experiments are more extensively recorded. In rats, rabbits, and dogs the s^i, s^p, and s^w series of multiple alleles is well established. Animals which are phenotypically s^p (piebald) have been studied in guinea pigs, mice, and *Peromyscus*. The amount of spotting varies, but its dependence on a gene recessive to *S* has been demonstrated. This is also true of cats.

Piebald individuals of uncertain genetic composition have been observed in tree squirrels (*Sciuridae*), beaver, hamster, lemmings (*Synaptomys*), and *Microtus*. In carnivores, they have been observed in wild Canidae, martens, and mink.

The extreme piebald s^ws^w type often borders on black-eyed or dark-eyed white phenotypes. There is opportunity for confusion in classification between the s^ws^w type and dark-eyed whites, due either to extreme dilution, c^e, in yellow or tan animals or to independent mutations of other loci. The complications in establishing homology in "dominant whites" will be further discussed under the *W* and other loci.

Among rodents, cases of extreme white spotting which may represent the s^w allele have been recorded in mice, guinea pigs, and *Microtus*, while in carnivores the wild Canidae, cat, blue fox, and marten have given examples. It should be remembered that the s^w locus is reasonably well established in rats, rabbits, and dogs.

M locus, W locus, V locus, etc.

There are a number of genes which, when present, are at least partially dominant and produce white spotting in various degrees. Certain of them may produce also a mottled, merled, or dappled coat. The house mouse possesses the most diversified and complete series. The other species in which genes with similar phenotypic or genotypic attributes (or both) are found are dogs, cats, mink, fox, and cotton rats (*Sigmodon*).

A rough comparison of the better known dominant spotting genes is provided in Table 3. The species, phenotype of heterozygote, and phenocopies of homozygotes are given in summary.

TABLE 3

Dominant spotting genes in rodents and carnivores

Species	Variety or gene	Heterozygote with +	Homozygote
Mouse	*W* series	White spotted with irregular spots	Black-eyed white lethal-anemic
Mouse	Varitint waddler	Merle with white spots	Black-eyed white
Mouse	Steel	White ventral spot; blaze	Lethal anemic; black-eyed white (embryonic)
Mouse	Splotch	White ventral spot occasional dorsal spots	Lethal, spina bifida, etc., embryonic
Cotton rat	Dominant spotting	White spotted with irregular spots	Lethal
Mink	Hedlund white	Blaze; ventral spot	Black-eyed white deaf
Mink	*S*, S^R	White-spotted with irregular spots	Black-eyed white head spot
Mink	*F*	Pale merled	Lethal
Dog	Merle	Merle with white spots	Black-eyed white; deaf; microphthalmic
Cat	Dominant white	White with small pigmented forehead spot	Deaf (at times)
Fox	Platinum	Pale with some white spots	Lethal

CONCLUSION

A review of coat color genes in rodents and carnivores is necessarily limited by qualities inherent in the problem of comparative genetics.

The availability of experimental data varies greatly in different species and may be roughly summarized as follows:

1. *Species with reasonably satisfactory data.* These include the house mouse, Norway rat, guinea pig, rabbit, *Peromyscus*, dog, cat, fox, and mink.
2. *Species with a small amount of breeding data.* Asiatic mouse, hamster, cotton rat, *Microtus*, raccoon, bear, skunk.
3. *Species with primarily or solely observational data.* All others listed in Tables 1 and 2.

The absence of histological data regarding the type and extent of melanin formation and distribution further handicaps the accurate evaluation and classification of phenotypes and their comparison as to genotypic similarities and differences. In spite of these handicaps, it is felt that maintenance and development of a "comparative" interest in the coat color of mammals will contribute to the continued increase in genetic information.

Genetic information on the formation and distribution of melanin pigment will be of continuing importance in its own right and a basic factor in the whole field of physiological genetics.

LIST OF LITERATURE

ALDOUS, C. M. 1939. A melanistic snowshoe hare from Maine. *J. Hered.*, 30: 25–26.

ALLEN, G. M. 1927. Dichromatism in a litter of red-backed mice. *J. Mammal.*, 8: 248.

ANKER, J. 1925. Die Vererbung der Haarfarbe bei Dachshunde. *Vi Danske. Vidensk. Selsk. Biol. Meddel.*, 4, No. 6.

ANTHONY, H. E. 1928. *Field Book of North American Mammals.* xxvi + 674 pp. G. P. Putnam's Sons, New York.

APGAR, C. S. 1930. A comparative study of the pelage of three forms of *Peromyscus*. *J. Mammal.*, 11: 485–493.

ATTFIELD, M. 1951. Inherited macrocytic anaemias in the house mouse. III. Red blood cell diameters. *J. Genet.*, 50: 250–263.

BAKER, M. R., and H. L. IBSEN. 1942. Two modifiers of self (*S*) and white spotting (*s*) in guinea pigs. *Genetics*, 27: 130.

BAMBER, R. C. 1927. Genetics of domestic cats. *Bibliogr. Genet.*, 3: 1–86.

——. 1933. Correlation between white coat colour, blue eyes and deafness in cats. *J. Genet.*, 27: 407–413.

——, and E. C. HERDMAN. 1925. A contribution to the study of the inheritance of black and yellow coat colour in cats. (Abstract). *Rep. Brit. Ass.*, 1925: 320–321.

——, and ——. 1927a. Dominant black in cats and its bearing on the question of tortoiseshell males—a criticism. *J. Genet.*, 18: 219–221.

BAMBER, R. C., and E. C. HERDMAN. 1927b. The inheritance of black, yellow and tortoiseshell coat-colour in cats. *J. Genet.*, 18: 87–97.

BAMBER, R. C. and E. C. HERDMAN. 1928. The problem of the tortoiseshell male cat. *Z. indukt. Abstamm.-Vererblehre*, 1: 387–390.

——, and ——. 1931. The incidence of sterility amongst tortoiseshell male cats. *J. Genet.*, 24: 355–357.

BARROWS, E. F. 1934. Modification of the dominance of agouti to non-agouti in the mouse. *J. Genet.*, 29: 9–15.

——. 1939. Selection for tail-spotting in the house mouse. *J. exp. Zool.*, 80: 107–111.

——, and J. M. PHILLIPS. 1915. Color in Cocker Spaniels. *J. Hered.*, 6: 387–397.

BARTO, E. 1941. Independent inheritance of certain characters in the deer mouse, *Peromyscus maniculatus*. *Pap. Mich. Acad. Sci.*, 27: 195–213.

BERNARD, H. 1941. An albino porcupine. *Canad. Fld. Nat.*, 55: 14.

BLAIR, W. E. 1940. Two cases of abnormal coloration in mammals. *J. Mammal.*, 21: 461–462.

——. 1954. A melanistic race of the white-throated packrat (*Neotoma albigula*). *J. Mammal.*, 35: 239–242.

BOWNESS, E. R. 1944. The pearl platinum fox. *Amer. Fur Breeder*, 17: 38–44 et al.

BRIGGS, L. C. 1940. Some experimental matings of color-bred white bull terriers. *J. Hered.*, 31: 135–136.

——, and N. KALISS. 1942. Coat color inheritance in bull terriers. *J. Hered.*, 33: 223–228.

BRAUCH, L. R., and W. L. RUSSELL. 1946a. Colorimetric measurement of the effects of the major coat color genes in the mouse on the quantity of yellow pigment in extracts. *Genetics*, 31: 212.

——, and ——. 1946b. A study of the physiological genetics of coat color in the mouse by means of the dopa reaction. *Genetics*, 31: 212.

BUNKER, H., and G. D. SNELL. 1948. Linkage of white and waved. *J. Hered.*, 39: 28.

BURNETT, W. L. 1925. Dichromatism and albinism in *Thomomys talpoides clusius*. *J. Mammal.*, 6: 129.

BURNS, M. 1943. Pigmentation and the genetics of colour in greyhounds. *Proc. roy. Soc. Edinb.*, 61B: 462–490.

——. 1952. *The Genetics of the Dog*. Commonweath Agricultural Bureaux, Bucks, England.

BUTLER, L. 1945. Distribution of genetics of the colour phases of the red fox in Canada. *Genetics*, 30: 39–50.

——. 1948. The genetics of the color phases of the red fox in the Mackenzie River locality. *Canad. J. Res.*, D, 25: 190–215.

CADY, M. 1945. Albino woodchuck. *All-Pets Mag.*, 16: 14–16.

CARR, J. G. 1947. Production of mutations in mice by 1:2:5:6 dibenzanthracene. *Brit. J. Cancer*, 1: 152–156.

CARTER, T. C. 1948. A new linkage in the house mouse; undulated and agouti. *Heredity*, 1: 367–372.

——. 1951a. The position of fidget in linkage group V of the house mouse. *J. Genet.*, 50: 264–267.

——. 1951b. The genetics of luxate mice. II. Linkage and independence. *J. Genet.*, 50: 300–306.

——, and D. S. FALCONER. 1952. A review of independent segregation in the house mouse. *J. Genet.*, 50: 399–413.

——, and H. GRÜNEBERG. 1950. Linkage between fidget and agouti in the house mouse. *J. Hered.*, 4: 373–376.

——, and R. S. PHILLIPS. 1950. Three recurrences of mutants in the house mouse. *J. Hered.*, 41: 252.

CASTLE, W. E. 1926a. On the pattern of the Dutch Rabbit. *J. Genet.*, 16: 189–196.

——. 1926b. Studies in color inheritance and of linkage in rabbits. *Publ. Carneg. Instn*, 337.

——. 1930a. *Genetics and Eugenics*. x + 474 pp. Harvard Univ. Press, Cambridge.

——. 1930b. *The Genetics of Domestic Rabbits*. Harvard Univ. Press, Cambridge.

——. 1934. Genetics of the Dutch coat pattern in rabbits. *J. exp. Zool.*, 68: 377–391.

——. 1944. Linkage of waltzing in the rat. *Proc. nat. Acad. Sci.*, Wash., 30: 226–230.

——. 1946a. Linkage in the albino chromosome of the rat. *Proc. nat. Acad. Sci., Wash.*, 32: 33–36.

——. 1946b. Mink mutation varieties. *J. Hered.*, 37: 215.

——. 1951a. Dominant and recessive black in mammals. *J. Hered.*, 42: 48–49.

——. 1951b. Variation in the hooded pattern of rats, and a new allele of hooded. *J. Genet.*, 36: 254–266.

——. 1952. Genetic linkage in the common rat, *Rattus norvegicus*. *Va. J. Sci.*, 3: 95–100.

——. 1953. Silver, a new mutation of the rat. *J. Hered.*, 44: 205–206.

——, and H. D. KING. 1947. Fawn, a new color dilution gene. *J. Hered.*, 38: 343–344.

——, and ——. 1949. Linkage studies of the rat. *Proc. nat. Acad. Sci., Wash.*, 35: 545–546.

——, and L. MOORE. 1937. Mutations of mink under domestication. *J. Hered.*, 37: 137–145.

——, and G. PINCUS. 1928. Hooded rats and selection. *J. exp. Zool.*, 50: 409–439.

——, and P. B. SAWIN. 1932. Contributions to the genetics of the domestic rabbit. *Publ. Carneg. Instn.*, 427.

——, and ——. 1941. Genetic linkage in the rabbit. *Proc. nat. Acad. Sci., Wash.*, 27: 519–523.

CERVA, F. A. 1931. Melanotische Exämplare des Ziesels (*Citellus citellus*). *Zool. Gart., Lpz.*, 4: 174.

CHARLES, D. R. 1938. Studies on spotting patterns. IV. Pattern variation and its developmental significance. *Genetics*, 23: 523–547.

CHASE, H. B. 1939a. Studies on the tricolor pattern of the guinea pig. I. The relation between different areas of the coat in respect to the presence of color. *Genetics*, 24: 610–621.

——. 1939b. Studies on the tricolor pattern of the guinea pig. II. The distribution of black and yellow as affected by white spotting and by imperfect dominance in the tortoise shell series of alleles. *Genetics*, 24: 622–643.

CLARK, F. H. 1934. The inheritance and linkage relations of a new recessive spotting in the mouse. *Genetics*, 19: 365–393.

——. 1936. Linkage of pink-eye and albinism in the deer-mouse. *J. Hered.*, 27: 259–260.

——. 1938a. Inheritance of cream coat color in *Microtus pennsylvanicus*, with a description of several other color varieties. *J. Hered.*, 29: 265–266.

——. 1938b. Inheritance and linkage relations of mutant characters in the deer-mouse *Peromyscus maniculatus*. *Contr. Lab. Vertebr. Genet., Univ. Mich.*, 7: 1–11.

——. 1938c. Inheritance of pectoral buff spotting in the cactus mouse, *Peromyscus eremicus*. *J. Hered.*, 29: 79–80.

——, and W. L. JELLISON. 1937. A pale mutation in the ground squirrel. *J. Hered.*, 28: 259–260.

CLOUDMAN, A. M., and L. E. BUNKER. 1945. The Varitint-waddler mouse, a dominant mutation in *Mus musculus*. *J. Hered.*, 36: 258–263.

CORKRUM, E. L. 1953. Aberrations in the color of the prairie vole, *Microtus ochrogaster*. *Trans. Kans. Acad. Sci.*, 56: 86–88.

COLE, L. J. 1945a. More concerning Dr. Osborn's mink. *Amer. Fur Breeder*, 17: 6–8.

——. 1945b. Breeding glacier blue and pearlatina foxes. *Nat. Fur News*, 17: 10.

COULOMBRE, J. L., and E. S. RUSSELL. 1954. Analysis of the pleiotropism at the *W* locus in the mouse: The effects of *W* and W^v substitution upon postnatal development of germ cells. *J. exp. Zool.*, 126: 277–295.

CROSS, E. C. 1941. Colour phases of the red fox (*Vulpes fulva*) in Ontario. *J. Mammal.*, 22: 25–39.

CUÉNOT, L. 1928. Génétique des souris. *Bibliogr. genet.*, 4: 179–242.

CURTIS, M. R., and W. E. DUNNING. 1937. Two independent mutations of the hooded or piebald gene of the rat and a study of pattern modifiers. *J. Hered.*, 28: 383–390.

——, and ——. 1940. An independent recurrence of the blue mutation in the Norway rat and a blue-black mosaic. *J. Hered.*, 31: 219–222.

DAHL, L. E., and T. QUELPRUD. 1937. Die Vererbung der Haarfarbe beim deutschen Boxer. *Z. Zücht. B*, 37: 159–177.

DANFORTH, C. H. 1927. Hereditary adiposity in mice. *J. Hered.*, 18: 153–162.

——. 1949. Snowball: A mutation in the cotton rat. *J. Hered.*, 40: 252–256.

DANIEL, J. 1938. Studies of multiple allelomorphic series in the house mouse. III. A spectrophotometric study of mouse melanin. *J. Genet.*, 36: 139–143.

DANNEEL, R., and P. HILDEGARD. 1940. Zur Physiologie der Kälteschwärzung beim Russenkaninchen. *Biol. Zbl.*, 60: 79–85.

——, and K. SCHAUMANN. 1938. Zur Physiologie der Kälteschwärzung beim Russenkaninchen. III. Die von dem Erbfaktoren an gesteuerte Fermentbildung in der Unterkühlungsphase. *Biol. Zbl.*, 58: 242–260.

DARLING, F. F., and P. GARDNER. 1933. A note on the inheritance of the brindle character in the coloration of Irish wolfhounds. *J. Genet.*, 27: 377–378.

DETLEFSEN, J. A. 1914. Genetic studies on a cavy species cross. *Publ. Carneg. Instn*, 205.

DICE, L. R. 1933. The inheritance of dichromatism in the deer-mouse *Peromyscus maniculatus blandus*. *Amer. Nat.*, 67: 571–574.

——. 1942. A family of dog-coyote hybrids. *J. Mammal.*, 23: 186–192.

DICKERSON, G. E., and J. W. GOWEN. 1947. Hereditary obesity and efficient food utilization in mice. *Science*, 105: 496–498.

DICKIE, M. M. 1954a. The expanding knowledge of the genome of the mouse. *J. nat. Cancer Inst.*, 15: 679–684.

——. 1954b. The tortoise shell house mouse. *J. Hered.*, 45: 158, 190.

——, and G. W. WOOLLEY. 1950. Fuzzy mice. *J. Hered.*, 41: 193–196.

DONCASTER, L. 1905. On the inheritance of coat color in rats. *Proc. Camb. phil. Soc.*, 13: 215–227.

DRY, F. W. 1928. The agouti coloration of the mouse (*Mus musculus*) and the rat (*Mus norvegicus*). *J. Genet.*, 20: 131–144.

DUNN, L. C. 1921. Unit character variation in rodents. *J. Mammal.*, 2: 125–139.

——. 1928. A fifth allelomorph in the agouti series of the house mouse. *Proc. nat. Acad. Sci., Wash.*, 14: 816–819.

——. 1937. Studies on spotting patterns. II. Genetic analysis of variegated spotting in house mice. *Genetics*, 22: 43–64.

——. 1942. Studies on spotting patterns. V. Further analysis of minor spotting genes in the house mouse. *J. Genet.*, 27: 258–267.

DUNN, L. C. 1945. A new eye color mutant in the mouse with asymmetrical expression. *Proc. nat. Acad. Sci., Wash.*, 31: 343–346.

——, and D. R. CHARLES. 1933. On the action of certain modifying genes in mice. *Amer. Nat.*, 67: 70.

——, and ——. 1937. Studies on spotting patterns. I. Analysis of quantitative variations in pied spotting of the house mouse. *Genetics*, 22: 14–42.

——, and W. EINSELE. 1938. Studies of multiple allelomorphic series in the house mouse. IV. Quantitative comparisons of melanins from members of the albino series. *J. Genet.*, 36: 145–152.

——, E. C. MACDOWELL, and G. A. LEBEDEFF. 1937. Studies on spotting patterns. III. Interaction between genes affecting white spotting and those affecting color in the house mouse. *Genetics*, 22: 307–318.

——, and J. MOHR. 1952. An association of hereditary eye defects with spotting. *Proc. nat. Acad. Sci., Wash.*, 38: 872–875.

——, and L. W. THIGPEN. 1930. The silver mouse. *J. Hered.*, 21: 495–498.

EATES, K. R. 1943. A black panther shot in Sind. *J. Bombay nat. Hist. Soc.*, 44: 291–293.

EATON, O. N. 1928. The occurrence of nose spots and tail spots in guinea pigs. *J. agric. Res.*, 37: 25–41.

——. 1943. Silvering in a strain of guinea pigs. *J. Hered.*, 34: 105–107.

——, and E. SCHWARZ. 1946. The "snowybelly" mouse. A dominant allele of the agouti series in the house mouse. *J. Hered.*, 37: 31–32.

ENGELS, W. L. 1948. White bellied house mice on some North Carolina coastal islands. *J. Hered.*, 39: 94–96.

ENGELSMEIER, W. 1937. Einfluss der Temperatur auf die Ausfärbung der Haare bei Kaninchen verschiedener Erbrassen. *Z. indukt. Abstamm.-u. Vererblehre*, 73: 601–616.

FALCONER, D. S. 1947. Genetics of "Snowybelly" in the house mouse. *J. Hered.*, 38: 215–219.

——. 1952. *Mouse News Lett.* No. 4, July, 1952, p. 3.

FEKETE, E., C. C. LITTLE, and A. M. CLOUDMAN. 1941. Some effects of the gene W^v (dominant spotting) in mice. *Proc. nat. Acad. Sci., Wash.*, 27: 114–117.

FELDMAN, H. W. 1935a. A fifth allelomorph in the albino series of the house mouse. *J. Mammal.*, 16: 207–210.

——. 1935b. The brown variation and growth of the house mouse. *Amer. Nat.*, 69: 370–374.

——. 1936a. Grizzle, a color character of the black rat. *Amer. Nat.*, 70: 502–504.

——. 1936b. Piebald characters of the deer-mouse. *J. Hered.*, 27: 301–304.

——. 1937. Segregation of mutant characters of deer mice. *Amer. Nat.*, 71: 426–429.

——, and G. PINCUS. 1926. On the inheritance of albinism and brown pigmentation in mice. *Amer. Nat.*, 60: 195–198.

FICHTER, E., and L. D. DAVIS. 1942. A pale variation in a ground squirrel. Notes on a pale individual of the thirteen-striped ground squirrel *Citellus tridecemlineatus tridecemlineatus* (Mitchill). *J. Hered.*, 33: 153–155.

FIELDER, J. H. 1952. The taupe mouse. *J. Hered.*, 43: 74–76.

FISHER, H. L. 1942. A white meadow mouse. *J. Mammal.*, 23: 336.

FISHER, R. A. 1949. A preliminary linkage test with agouti and undulated mice. *J. Hered.*, 3: 229–241.

——. 1953. The linkage of polydactyly with leaden in the house mouse. *J. Hered.*, 7: 91–95.

——, and G. D. SNELL. 1948. A twelfth linkage group in the house mouse. *J. Hered.*, 2: 271–273.

FLETCHER, J. L. 1944. The occurrence of a "silver" type muskrat. *J. Hered.*, 35: 351–352.

FOOKS, H. A. 1941. A pale colour form of the panther. *J. Bombay nat. Hist. Soc.*, 42: 435.

FOOTE, C. L. 1949. A mutation in the golden hamster. *J. Hered.*, 40: 101.

FORTUYN, A. B. D. 1939. A mutation from agouti with recessive spotting to dominant spotting in *Mus musculus*. *Genetica*, 21: 92–96.

FOSTER, M. 1952. Inherited variations in the tyrosinase system in the guinea pig. *Genetics*, 37: 581.

FRASER, A. S., S. SOBEY, and C. C. SPICER. 1953. Mottled, a sex-modified lethal in the house mouse. *J. Genet.*, 51: 217–221.

FRYXELL, F. M. 1928. Melanism among the marmots of the Teton range—Wyoming. *J. Mammal.*, 9: 336–337.

GATES, W. H. 1928. Linkage of the factors for short-ear and density in the house mouse. *Genetics*, 13: 170–179.

——, and T. PULLIG. 1945. The linkage of dominant white spotting with hairless in the house mouse. *Genetics*, 30: 4.

GENETTI, A. H. 1944. A success at cross-breeding mink. *Black Fox Mag.*, 28: 17.

GERSHENSON, S. 1945. Distribution of black hamsters in the Ukrainian U. S. S. R. *C. R. (Doklady) Acad. Sci. U. S. S. R.*, 47: 598–601.

GERSHENSON, S., and V. POLEVOI. 1941. Mating system in a natural population of the common hamster. *C. R. (Doklady) Acad. Sci. U. S. S. R.*, 30: 64–65.

GILDOW, E. M. 1944. Some color mutations in foxes and mink. *Fur J.*, 11: 12–15.

GINSBURG, B. 1944. The effects of the major genes

controlling coat color in the guinea-pig on the dopa oxidase reaction of skin extracts. *Genetics*, 29: 176–198.

GREEN, C. V. 1930. Inheritance in a mouse species cross. *Amer. Nat.*, 64: 540–544.

GROBMAN, A. B., and D. C. CHARLES. 1947. Mutant white mice. *J. Hered.*, 38: 381–384.

GRÜNEBERG, H. 1935. A new sub-lethal colour mutation in the house mouse. *Proc. roy. Soc.*, B, 118: 321–342.

——. 1936. Grey-lethal, a new mutation in the house mouse. *J. Hered.*, 27: 105–109.

——. 1937. A reverse mutation in the rat (*Mus norvegicus*). *J. Genet.*, 35: 177–181.

——. 1942a. The anaemia of flexed-tail mice (*Mus musculus* L.). I. Static and dynamic hematology. *J. Genet.*, 43: 45–68.

——. 1942b. The anaemia of flexed-tail mice. II. Siderocytes. *J. Genet.*, 44: 246–271.

——. 1942c. Inherited macrocytic anaemias in the house mouse. II. Dominance relationships. *J. Genet.*, 43: 285–293.

——. 1952. *The Genetics of the Mouse*. 2nd edition. xiv + 650 pp. Nijhoff, The Hague.

——. 1953. The relations of microphthalmia and white in the mouse. *J. Genet.*, 51: 359–362.

GUNN, C. K. 1945. Genetics of some new type foxes. *Canad. Dept. Agri. Publ. Tech. Bull.*, 768: 1–14.

HACHLOV, V. 1930. Über die Genetik der Hunde. *Züchter*, 2: 261–263.

HADJIDIMITROSS, P. 1933. Die Pigmentverteilung in Kaninchenhaar. *Z. Zücht.*, 27B: 243–266.

HARMAN, M. T., and A. A. CASE. 1941. Genetic aspects of pigment production in the guinea pig. *Genetics*, 26: 474–486.

HATT, R. T. 1930. Color varieties of Long Island mammals. *J. Mammal.*, 11: 322–323.

HAVEN, H. M. W. 1927. Notes of Mammals. *Maine Nat.*, 7: 160.

HEIDENTHAL, G. 1940. A colorimetric study of genic effect on guinea pig coat color. *Genetics*, 25: 197–214.

HUESTIS, R. R. 1938. Ivory, a feral mutation in *Peromyscus*. *J. Hered.*, 29: 235–237.

——. 1946. Linkage of flexed tail and albinism in *Peromyscus*. *Genetics*, 31: 219.

——. 1948. Red-eyed *Peromyscus maniculatus*. *Genetics*, 33: 613.

——, and E. BARTO. 1932. A new yellow *Peromyscus*. *Science*, 76: 255–256.

——, and ——. 1934. Brown and silver deer mice. *J. Hered.*, 25: 219–223.

——, and V. PIESTRAK. 1942. An aberrant ratio in *Peromyscus*. *J. Hered.*, 33: 289–291.

IBSEN, H. L., and B. L. GORTZEN. 1951a. Roan, a modifier of pigmented hairs in guinea pigs. *J. Hered.*, 42: 267–269.

——, and ——. 1951b. Whitish, a modifier of chocolate and black hairs in guinea pigs. *J. Hered.*, 42: 231–236.

ILJIN, N. A. 1926. The ruby eye in animals and its heredity. *Trans. Lab. exp. Biol. Zoopark Moscow*, 1926: 107–129.

——. 1931. Über die Vererbung der Färbung beim Dobermann-Pinscher. *Züchter*, 3: 370–376.

——. 1941. Wolf-dog genetics. *J. Genet.*, 42: 359–414.

ILJIN, H. A., and V. N. ILJIN. 1930. Temperature effects on the color of the Siamese cat. *J. Hered.*, 21: 309–318.

JACOBI, A. 1927. Melanismen einheimischer Kleinsäuger (*Neomys fodiens* und *Cricetus cricetus*). *Z. Säugetierk.*, 2: 82–87.

JEX, H. S. 1953. "Jew's-harp" marking in the forehead of a white cat. *J. Hered.*, 44: 58.

JOHANSSON, I. 1947. The inheritance of the platinum and white face characters of the fox. *Hereditas*, 33: 153–174.

JONES, S. V. H. 1923. Color variations in wild animals. *J. Mammal.*, 4: 172–177.

KALISS, N. 1942a. The inheritance of "white-belly" in the house mouse. *J. Hered.*, 33: 21–23.

——. 1942b. The morphogenesis of pigment in the hair follicle of the house mouse. *J. Morph.*, 70: 209–218.

KEELER, C. E. 1931a. The independence of dominant spotting and recessive spotting (piebald) in the house mouse. *Proc. nat. Acad. Sci., Wash.*, 17: 101–102.

——. 1931b. A reverse mutation from "dilute" to "intense" pigmentation in the house mouse. *Proc. nat. Acad. Sci., Wash.*, 17: 497–499.

——. 1931c. A mutation to dominant spotting (*W*) in the house mouse. *J. Hered.*, 22: 273–276.

——. 1931d. A probable new mutation to white-belly in the house mouse, *Mus musculus*. *Proc. nat. Acad. Sci., Wash.*, 17: 700–703.

——. 1933. Akhissar spotting of the house mouse. *Proc. nat. Acad. Sci., Wash.*, 19: 477–481.

——. 1935. Head dot: an incompletely recessive white spotting character of the house mouse. *Proc. nat. Acad. Sci., Wash.*, 21: 379–383.

——, and V. COBB. 1933. Allelomorphism of silver and Siamese coat variations in the domestic cat. *J. Hered.*, 24: 181–184.

KING, H. D. 1932. Mutations in a strain of captive gray rats. *Proc. 6. int. Congr. Genet.*, 2: 250.

KLUGH, A. B. 1927. Ecology of the red squirrel. *J. Mammal.*, 8: 1–32.

KOHTS, A. 1948. A variation of colour in the common wolf and its hybrids with the domestic dogs. *Proc. zool. Soc. Lond.*, 117: 784–790.

KOLLER, P. 1930. On pigment formation in the *D*-black rabbit. *J. Genet.*, 22: 103–107.

KOMAI, T. 1952a. Incidence of genes for coat colors in Japanese cats. *Annot. zool. jap.*, 25: 209–211.

——. 1952b. On the origin of the tortoiseshell male cat—a correction. *Proc. Jap. Acad.*, 28: 150–155.

KOPEC, S. 1927. A case of spotting in a Himalayan rabbit and its probable explanation. *Biol. gen.*, 3: 411–418.

LAMBERT, W. V. 1935. Silver guinea-pigs—a recessive color variation. *J. Hered.*, 26: 279–283.

LEA, A. J. 1943. The inheritance of coat and nose colour in longhaired dachshunds. *J. Genet.*, 45: 197–205.

LITTLE, C. C. 1913. Experimental studies of the inheritance of color in mice. *Publ. Carneg. Instn.*, 179: 11–102.

——. 1914. Coat color in Pointer Dogs. *J. Hered.*, 5: 244–248.

——. 1928. Preliminary report on a species cross in rodents, *Mus musculus* x *Mus wagneri* (*bactrianus*). *Pap. Mich. Acad. Sci.*, 8: 393–399.

——. 1934. Inheritance in Toy Griffons. *J. Hered.*, 25: 198–200.

——. 1957. *The Inheritance of Coat Color in Dogs.* Comstock Publishing Associates, Ithaca, N.Y.

——, and A. M. CLOUDMAN. 1937. The occurrence of a dominant spotting mutation in the house mouse. *Proc. nat. Acad. Sci., Wash.*, 23: 535–537.

——, and K. P. HUMMEL. 1947. A reverse mutation to a "remote" allele in the house mouse. *Proc. nat. Acad. Sci., Wash.*, 33: 42–43.

——, and E. E. JONES. 1919. The inheritance of coat color in Great Danes. *J. Hered.*, 10: 309–320.

MACDOWELL, E. C. 1950. Light—a new mouse color. *J. Hered.*, 41: 35–36.

MALLYON, S. A. 1951. A pronounced sex difference in recombination values in the sixth chromosome of the house mouse. *Nature, Lond.*, 168: 118–119.

MANVILLE, R. H. 1955. Dichromatism in Michigan rodents. *J. Mammal.*, 36: 293.

MARCHLEWSKI, T. 1929. Studies on silvering in rabbits. III. A factor inhibiting uniform colouring. *Bull. Int. Acad. Cracovie* (*Acad. pol. Sci.*) Ser. B., 1929 (7): 263–268.

——. 1930. Genetic studies on the domestic dog. *Bull. int. Acad. Cracovie* (*Acad. pol. Sci.*), 1930 (1/5): 117–145.

——. 1934. Two cases of reverse mutations in the colour factors of rabbits. *J. Genet.*, 29: 153–157.

——. 1946. Studies on the evolution of dominance in mammals. *Bull. int. Acad. Cracovie* (*Acad. pol. Sci.*), 1946–7: 107–110.

MARKERT, C. L., and W. K. SILVERS. 1956. The effects of genotype and cell environment on melanoblast differentiation in the house mouse. *Genetics*, 41: 429–450.

MATHER, K., and S. B. NORTH. 1940. Umbrous: a case of dominance modification in mice. *J. Genet.*, 40: 229–241.

MCCARLEY, W. H. 1951. Color mutations in a small partially isolated population of pocket gophers (*Geomys breviceps.*) *J. Mammal.*, 32: 338–341.

MCINTOSH, W. B. 1956. Whiteside, a new mutation in *Peromyscus. J. Hered.*, 47: 28–32.

MERTENS, R. 1929. Ein weisser Kanadabiber (*Castor canadensis* Kuhl). *Ber. Senckenb. Naturf. Ges.*, 59: 423.

MILLER, D. S., and M. Z. POTAS. 1955. Cordovan, a new allele of black and brown color in the house mouse. *J. Hered.*, 46: 293–296.

MITCHELL, A. L. 1935. Dominant dilution and other color factors in collie dogs. *J. Hered.*, 26: 424–430.

MOHR, E. 1939. Akromelanismus bei *Mus musculus. Zool. Anz.*, 126: 45–46.

MOORE, L., and C. E. KEELER. 1947. Note on certain mendelian ratios in mink. *J. Hered.*, 38: 380.

MOUSE NEWS LETTER. 1949–1956. Lab. Animals Bur., London.

MOUTSCHEN, J. 1950. Some hereditary peculiarities of the Siamese cat. *Bull. Nat. belges*, 31: 200–203.

MURRAY, J. M. 1931. A preliminary note on the occurrence of a color mutation in the house mouse. *Science*, 73: 482.

——. 1936. "Leaden," a recent color mutation in the house mouse. *Amer. Nat.*, 67: 278–283.

——, and C. V. GREEN. 1933. Inheritance of ventral spotting in mice. *Genetics*, 18: 481–486.

——, and G. D. SNELL. 1943. Belted, a new recessive spotting mutation in the mouse. *Anat. Rec.*, 87: 458.

——, and ——. 1945. Belted, a new sixth chromosome mutation in the mouse. *J. Hered.*, 36: 266–268.

NACHTSHEIM, H. 1930. Neue Untersuchungen über multiplen Allelomorphismus bei Kaninchen. *Z. indukt. Abstamm. -u. Vererblehre*, 54: 272–276.

NORTON, C. C. 1944. Albinos again. *All-Pets Mag.*, 16: 63.

OKSALA, T. 1954. Genetics of the dark phases of the red fox in experiment and in nature. *Pap. Game-Res., Helsingf.*, 11: 1–6.

ORR, R. T. 1941. Yellow mutation in the California meadow mouse, *Microtus californicus. Wasmann Collect.*, 4: 129–130.

ORSINI, M. W. 1952. The piebald hamster. *J. Hered.*, 43: 37–40.

OWEN, R. D., and R. M. SHACKELFORD. 1942. Color aberrations in *Microtus* and *Pitymys. J. Mammal.*, 23: 306–314.

PATTERSON, A. H. 1927. Albino rats. *Trans. Norfolk Norw. Nat. Soc.*, 12: 380.

PEARSON, K., and C. H. USHER. 1929. Albinism in Dogs. *Biometrika*, 21: 144–163.

PEASE, M. S. 1933. Blue: Dutch—a new linkage in rabbits? *Proc. 5th World's Poultry Congr.*, 3: 503; summ., 4: 125.

PETZSCH, H. 1940. Verebungsuntersuchungen an Farbspielen des Hamsters (*Cricetus cricetus*). *Z. Zücht., B*, 48: 67–83.

PHILLIPS, J. M. 1937. Albinism in a Cocker Spaniel. *J. Hered.*, 28: 103–104.

——. 1938. Sable coat color in Cockers. *J. Hered.*, 29: 67–69.

——, and E. D. KNIGHT. 1938. Merle or calico foxhounds. *J. Hered.*, 29: 365–367.

PICTET, A. 1930. Sur l'existence de deux panachures des cobayes, l'une dominante, l'autre récessive. *C. R. Soc. Phys. Hist. nat. Gèneve*, 47: 118–121.

——. 1940. Recherches sur l'hèrèditè de la dilution et du blanchiment du pelage dans la genre *Cavia*. *Genetica*, 22: 1–122.

—— and A. FERRERO. 1936. Hérédité d'une nouveauté de pelage: le cobaye argentè. *Arch. Sci. phys. nat.*, 18: 74–79.

PINCUS, G. 1931. A modifier of piebald spotting in mice. *Amer. Nat.*, 65: 283–286.

POCOCK, R. I. 1907. On English domestic cats. *Proc. zool. Soc., Lond.*, B, 79.

PONOMAREV, A. L. 1938. On the variability and inheritance of colour and pattern in the sable, *Martes zibellina* L. *Zool. Zh.*, 17: 482–504.

PUGH, C. E. M. 1933. Tyrosinase from the skin of certain black rabbits. *Biochem. J.*, 27: 475–479.

PULLIG, T. 1949. A new recessive spotting gene in the house mouse. *J. Hered.*, 40: 228–230.

PUNNETT, R. C. 1926a. Note on a Chinchilla-Japanese cross in rabbits. *J. Genet.*, 17: 217–220.

——. 1926b. The Dutch rabbit—Castle, Pease and Punnett. *J. Genet.*, 16: 197–199.

——. 1928. Further notes on Dutch and English rabbits. *J. Genet.*, 20: 247–260.

——. 1930. On the series of allelomorphs connected with the production of black pigment in rabbits. *J. Genet.*, 23: 265–274.

RAWLES, M. E. 1948. Origin of melanophores and their role in the development of color patterns in vertebrates. *Physiol. Rev.*, 28: 383–408.

REED, S. C., and G. SANDER. 1937. Time of determination of hair pigments in the mouse. *Growth*, 1: 194–200.

RITCHIE, J. 1926. Abnormal coloration in Scottish mountain hares. *Scot. Nat.*, 1926: 11–15.

ROBERTS, E. 1929. A blue mutation in the rat (*Mus norvegicus*). *Science*, 70: 334.

——. 1931. A new mutation in the house mouse (*Mus musculus*). *Science*, 74: 569.

——, and J. H. QUISENBERRY. 1935. Linkage of the genes for nonyellow (*a*) and pink eye (*p2*) in the house mouse. *Amer. Nat.*, 69: 181–183.

ROBINSON, R. 1951. Dutch-type white-spotting in rabbits. *Nature, Lond.*, 168: 300.

——. 1955. Two new mutations in the Syrian hamster. *Nature, Lond.*, 176: 353–354.

RUSSELL, E. S. 1939. A quantitative study of genic effects on guinea-pig coat colors. *Genetics*, 24: 332–355.

——. 1946a. A quantitative study of genic effects on coat color in the house mouse. *Genetics*, 31: 227–228.

——. 1946b. A quantitative histological study of the pigment found in the coat color mutants of the house mouse. I. Variable attributes of the pigment granules. *Genetics*, 31: 327–346.

——. 1948. A quantitative histological study of the pigment found in the coat color mutants of the house mouse. II. Estimates of the total volume of pigment. *Genetics*, 33: 228–236.

——. 1949a. A quantitative histological study of the pigment found in the coat color mutants of the house mouse. III. Interdependence among the variable granule attributes. *Genetics*, 34: 133–145.

——. 1949b. A quantitative histological study of the pigment found in the coat color mutants of the house mouse. IV. The nature of the effects of genic substitutions in five major allelic series. *Genetics*, 34: 146–166.

——. 1949c. Analysis of pleiotropism at the *W* locus in the mouse. *Genetics*, 34: 708–723.

——, E. L. FONDAL, and J. L. COULOMBRE. 1948. Preliminary analysis of the pleiotropism at the *W* locus in the mouse. *Genetics*, 33: 627.

——, and W. L. RUSSELL. 1943. A quantitative histological study of the genic effects on coat color in the house mouse. *Genetics*, 28: 87–88.

RUSSELL, W. L. 1947. Splotch, a new mutation in the house mouse, *Mus musculus*. *Genetics*, 32: 102.

SARVELLA, P. A. 1954. Pearl, a new spontaneous coat and eye color mutation in the house mouse. *J. Hered.*, 45: 19–20.

SAWIN, P. B. 1932. Hereditary variation of the chinchilla rabbit. *J. Hered.*, 23: 39–46.

——. 1934. Linkage of "wide-band" and agouti genes. The agouti gene and a modifier shown to be situated on the same chromosome in the domesticated rabbit. *J. Hered.*, 25: 477–481.

SCHILLING, L. 1939. Untersuchungen zur Variabilität der Meerschweinchenhaare und ihrer Pigmente. *Z. indukt. Abstamm. -u. Vererblehre*, 76: 535–568.

SCHNEIDER, K. M. 1930. Ein Fall von erblichem partiellen Albinismus bei Löwen. *Zool. Gart., Lpz.*, 2: 274–278.

SCHULTZ, W. 1931. Methoden zur Darstellung versteckter mendelnder Erbanlagen durch ihre Aktivierung ohne Kreuzung, besonders die Kältepigmentierung weisser Haare und roter Albinoaugen. In Aberhalden, E., *Handbuch der biologischen Arbeitsmethoden*, Teil 3, Heft 6, pp. 1055–1112. Urban & Schwarzenberg, Berlin.

——. 1935. Ein Voll-Albino mit kälteschwärtzbarer Iris und unmittelbarer Aktivierbarkeit seiner versteckten Färbungs-Gene. *Biol. Zbl.*, 55: 384–385.

SEARLE, A. G. 1949. Gene frequencies in London cats. *J. Genet.*, 49: 214–220.

—. 1952. A lethal allele of dilute in the house mouse. *J. Hered.*, 6: 395–401.

SEREBRENNIKOV, M. K. 1931. On the polychromatism and albinism of the Siberian squirrels. *Proc. Zool. Soc., Lond.* 1931(2): 493–495.

SHACKELFORD, R. M. 1941. Mutations in minks. *Trans. Wis. Acad. Sci. Arts Lett.*, 34: 45.

——. 1948. The nature of coat color differences in mink and foxes. *Genetics*, 33: 311–336.

——. 1949. Six mutations affecting coat color in ranch-bred mink. *Amer. Nat.*, 83: 49–67.

——, and L. J. COLE. 1947. "Screw Neck" in the pastel color phase of ranch-bred mink. *J. Hered.*, 38: 203–209.

——, and W. D. MOORE. 1954. Genetic basis of some white phenotypes in the ranch mink. *J. Hered.*, 45: 173–176.

SHERMAN, H. B. 1951. Aberrant color phases of the cotton rat, *Sigmodon*. *J. Mammal.*, 32: 217.

SLAGSVOLD, P. 1949. Inheritance of blue and white color in the polar fox. *Nord. Vet. Med.*, 1: 429–441.

SMITH, S. E., C. H. WHITAKER, L. E. DAVIDS, and P. V. NOBLE. 1941. The inheritance of three coat color mutations in ranch-raised minks. *J. Hered.*, 32: 173–176.

SNYDER, L. L. 1930. Color mutants in *Microtus*. *J. Mammal.*, 11: 83.

SORSBY, A., and J. B. DAVEY. 1954. Ocular associations of dappling (or merling) in the coat color of dogs. *J. Genet.*, 52: 425–440.

STRONG, L. C. 1947. The induction of germinal mutations by chemical means. *Amer. Nat.*, 81: 50–59.

——, and W. E. HOLLANDER. 1953. Two non-allelic mutants resembling "*W*" in the house mouse. *J. Hered.*, 44: 41–44.

SUMNER, F. B. 1928. Observations on the inheritance of a multifactor color variation in the white-footed mouse (*Peromyscus*). *Amer. Nat.*, 62: 193–206.

THEVENIN, R. 1945. Quelques observations sur le pelage des chats domestiques. *Bull. Soc. Nat. Acclim. Fr.*, 92: 1–14.

THOM, W. S. 1944. A black leopard, an ordinary leopard and a good bull tsaing. *J. Bombay nat. Hist. Soc.*, 44: 374–379.

THOMPSON, J. C., V. C. COBB, C. E. KEELER, and M. DMYTRYK. 1943. Genetics of the Burmese cat. *J. Hered.*, 34: 119–123.

TJEBBES, K., and C. WRIEDT. 1926. Dominant black in cats and its bearing on the question of the tortoise shell males. *J. Genet.*, 17: 207–209.

——, and ——. 1927a. The albino factor in the samojede dog. *Hereditas*, 10: 165–167.

——, and ——. 1927b. Dominant black in cats and tortoise shell males.—A reply. *J. Genet.*, 19: 131.

VAN INGEN and VAN INGEN. 1941. Variation in colour of tigers and panthers. *J. Bombay nat. Hist. Soc.*, 42: 654–655.

VON BLOEKER, J. C., JR. 1930. An albino kangaroo rat. *J. Mammal.*, 11: 237.

WACHTER, W. L. 1927. Linkage studies in mice. *Genetics*, 12: 108–114.

WALLACE, M. E. 1953. A case of mutual reduction of dominance: observed in *Mus musculus*. *Heredity*, 7: 435–437.

——. 1954. A mutation or a cross-over in the house mouse? *Heredity*, 8: 89–105.

WARREN, D. C. 1927. Coat color inheritance in greyhounds. *J. Hered.*, 18: 513–522.

WARREN, E. R. 1929. An albino field mouse. *J. Mammal.*, 10: 82.

WATCHORN, E. 1938. Some biochemical data on the grey-lethal mouse. *J. Genet.*, 36: 171–176.

WHITING, P. W. 1918. Inheritance of coat color in cats. *J. exp. Zool.*, 25: 539–569.

WHITNEY, L. F. 1928. The inheritance of a ticking factor in hounds. *J. Hered.*, 19: 498–502.

——. 1931. The raccoon and its hunting. *J. Mammal.*, 12: 29–38.

WHITTINGHILL, M. 1944. Concerning linkage of waltzing in rats. *Proc. nat. Acad. Sci., Wash.*, 30: 221–226.

WINGE, Ø. 1946. On the bicolour gene in the dog. *C. R. Lab. Carlsberg*, 24: 125–132.

——. 1950. *Inheritance in Dogs, with Special Reference to Hunting Breeds*. 153 pp. Comstock Publ. Co., Ithaca.

WOLFF, D. 1942. Three generations of deaf white cats. *J. Hered.*, 33: 39–43.

WOOLLEY, G. W. 1941. "Misty," a new coat color dilution in the mouse, *Mus musculus*. *Amer. Nat.*, 75: 507–508.

——. 1943. "Misty," a new coat color dilution in the mouse, *Mus musculus*. *Genetics*, 28: 95–96.

——. 1945. Misty dilution in the mouse. *J. Hered.*, 36: 281–284.

WRIGHT, M. E. 1947. Undulated: A new genetic factor in *Mus musculus* affecting the spine and tail. *Heredity*, 1: 137–141.

WRIGHT, S. 1917a. I. Color inheritance in mammals. *J. Hered.*, 8: 224–235.

——. 1917b. II. Color inheritance in the mouse. *J. Hered.*, 8: 373–378.

——. 1917c. III. Color inheritance in the rat. *J. Hered.*, 8: 426–430.

——. 1917d. IV. Color inheritance in the rabbit. *J. Hered.*, 8: 473–475.

——. 1917e. V. Color inheritance in the guinea pig. *J. Hered.*, 8: 476–480.

——. 1917f. VI. Color inheritance in cattle. *J. Hered.*, 8: 521–527.

——. 1917g. VII. Color inheritance in the horse. *J. Hered.*, 8: 561–564.

——. 1926. Effects of age of parents on characteristics of the guinea pig. *Amer. Nat.*, 60: 552–559.

——. 1927. The effects in combination of the major color-factors of the guinea-pig. *Genetics*, 12: 530–569.

——. 1949. Estimates of amount of melanin in the hair of diverse genotypes of the guinea pig from transformation of empirical grades. *Genetics*, 34: 245–271.

——, and Z. I. BRADDOCK. 1949. Colorimetric determination of the amounts of melanin in the hair of diverse genotypes of the guinea pig. *Genetics*, 34: 223–244.

——, and H. B. CHASE. 1936. On the genetics of the spotted pattern of the guinea pig. *Genetics*, 21: 758–787.

——, and O. N. EATON. 1926. Mutational mosaic coat patterns of the guinea pig. *Genetics*, 11: 333–351.

ZINN, D. J. 1954. Albino chipmunks in Rhode Island. *J. Mammal.*, 35: 585–586.

NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

REVIEWS AND BRIEF NOTICES

GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

THE LIBERAL ARTS COLLEGE. *A Chapter in the American Cultural History.*

By George P. Schmidt. Rutgers University Press, New Brunswick. $6.00. viii + 310 pp.; ill. 1957.

Joseph Krutch once wrote, "Time was when the scientist, the poet, and the philosopher walked hand in hand. In the universe which the one perceived the other found himself comfortably at home. But the world of modern science is one in which the intellect alone can rejoice." Although written 30 years ago, these words still ring true, for in living in this galactic immensity we call the universe we find ourselves, collectively, a lonely, frightened people searching for things that money cannot buy. Yet, paradoxically, it is modern science alone which has shaped our modern mind, fixed the base of our contemporary living, and freed us from the encumbering meshes of superstition, ignorance, and parochialism.

We live in a world, and more particularly in that part we call Western civilization, of enormous technological advancement which, through translation from discoveries in the basic sciences, has given us a material comfort and welfare undreamed of by the wildest optimist. It is also a world that has bred an equally enormous intellectual arrogance, but so lacking in philosophical depth and an understanding of what Whitehead calls "the insistent present" that it is staggered and panicked by the onrushing atomic age, and by the thought that another civilization—and a threatening one—is capable of equally substantial scientific effort, achievement, and—we might as well face it—destruction. Why is this so? Have we so lost our philosophical and humanistic urbanity and equilibrium that we are no longer capable of rational adjustment to prevailing conditions or of a societal recovery that is consistent with what is good in terms of human traditions and values?

Answers to these questions—and quickly—are needed, and it is only natural that we look to our educational systems as a first step in seeking a solution, for within the framework of these systems lies the chief responsibility for the cultural life of a nation—the responsibility for the propagation, extension, reappraisal, and ferment of ideas and principles that guide, mold, arbitrate, and lead us. It is fortunate, therefore, in this period when the restoration of American learning is being considered by so many people, informed and uninformed, for us to secure a volume that deals with the core of our educational system, the liberal arts college.

Let us first ask, "What is a liberal education and what has it to do with our way of life?" Quite frankly, it has nothing to do with professionalism or vocational-

ism. The introduction of these aspects of education into our liberal programs—prevalent as they are today—can only sap their strength and dilute their value. Equally frankly, it is concerned with the development of an aristocracy—not of class or wealth or society or nation, but an individual aristocracy of mind, taste, and personality. It seeks to develop the uncommon, not the common, man. Our hereditary legacy is such that each of us is unique—absolutely unique in a very real and tangible sense; if a liberal education has a single goal for the individual, it is the development of that uniqueness to the fullest, though tempered, however, by that urbanity, that humaneness that comes with sensitivity, discrimination, understanding, appreciation, and self-criticism. We tend to believe that this comes through an acquaintance with great literature and art and the pageantry of history, but a study of the sciences, divorced from its customary professionalism, can be one of the great liberalizing forces in our day. It is, indeed, one of the tragedies of modern education that so many students pass through our colleges without exposure to the philosophies, methods, and triumphs of science. In this sense I think it can be more truly said that our science students are more liberally educated than are those in the humanities and social sciences. But, all too frequently, they are equally narrowly trained, for their scientific education, however technically sound, rarely provides them with the philosophic perspective for viewing their subject as only a single facet of human endeavor.

But what of our so-called liberal arts colleges? Are they performing their traditional and expected roles? Are they indeed worthy of their name? A reading of Schmidt's volume indicates that no single unqualified answer can be given.

The liberal arts college, despite its enormous diversity in character, size, and scholarly attainment, is an institution peculiarly American. A transplanted root of Oxford and Cambridge, it took hold in America like an introduced weed with no natural enemies, spreading across the new-opened land with the rapidity and tenacity of the dandelion. Beginning in New England and Virginia, the colleges were variously backed by church, state, and community; their finances were even more haphazard than they are today; their students were generally ill-prepared (a perennial complaint), for many colleges were founded without an adequate sustaining secondary school system; and their curricula were solidly classical. Then, as now, "the Diadem of the President" was a "Crown of Thorns," as the Reverend Stiles, an early president of Yale College, so aptly put it.

But the liberal arts college is an organic living institution, and like other organic things, it has had an evolution. Under the domination of the complex universities, particularly those of the states which were pledged to the idea of service, the college began to lose its classical identity. The general acceptance of Darwinism not only gave science a foothold it has not relinquished but also carried with it ideas of flux and experimentation. The elective system of Eliot gave impetus to the change until, in some colleges, administrations were attempting to out-do Dewey in student freedom and progressiveness. Not all schools have followed suit, for some have closely adhered to their earlier "vision of greatness," but the pressures of our dynamic and demanding society are such as to convert our colleges into becoming a mere reflection of its complexity instead of remaining the fountainhead of leadership and the trainer of leaders.

The Spanish philosopher, Julian Marias, in his book *Modern Age* has contrasted the American with the European system of education. As he sees the role of a university, it can impart to the student three things: "knowledge of a subject, the scheme of ideas of an epoch, and a system of beliefs and modes of behavior." The last of these three Marias considers to be most important in American education, his point of view being based on his belief that an American education can be savored to its fullest only by being lived in, i.e., by being a residential college. The emphasis therefore is on the development of personality. In his words, the American point of view is that "the formation of personality requires (among other things) scientific instruction"; the European philosophy, quite the opposite, considers that "the formation of personality comes about as a consequence of scientific instruction." This is perhaps a somewhat novel way of pointing up the differences that exist between these two educational systems, but it does suggest the emphasis we place on the multitude of activities that constitute American education.

Marias' analysis, however, does not indicate the vigor of the liberal arts college. Despite its departure from classical traditions, its uncertain directions, and its seemingly endless experiments, the liberal arts college is not complacent. It is conscious of its weaknesses as well as its strengths, and it is not afraid of change. Therein lies its hope for itself and for the nation. It has served us well; it will undoubtedly continue to do so in the future. Schmidt makes this quite clear in his well-done historical account of its evolution.

C. P. SWANSON

THE AMERICAN UNIVERSITY OF THE TWENTIETH CENTURY.

By William Clyde DeVane. Louisiana State University Press, Baton Rouge. $2.50. xi + 72 pp. 1957.

These are dog days for education, educators, and students. Outer space has been breached and we were not the first to penetrate the barrier; a burgeoning population threatens to inundate our colleges and universities at a time when men, money, and facilities are desper-

ately needed; the quality and quantity of teachers cannot meet the needs, particularly now at precollege levels and later most certainly at all levels; our methods and aims of education are suspect; our technological age demands trained personnel at a time when a wave of anti-intellectualism seemed to have swept through our student body. An open hysteria is evident everywhere, and the hot breath of criticism comes oppressively from all sides to sear the very soul of American education. Meanwhile the governments — local, state, and national — are trying frantically to bring in cooling rains by seeding the clouds with salary increases, scholarships, preferential treatment for teachers of mathematics and the sciences, and stiffer and more scientific programs for students. There is no certainty, however, that cloud-seeding could provide anything other than very temporary relief. Sound corrective measures, which should come from within our educational systems, seem obvious by their absence, but there are few of us who would deny that the hot seat occupied by education is one of its own design and construction.

Our educational system is an intimately structured one, with each higher level built upon those beneath it. Educators have the natural tendency to blame the lower levels for the inadequacy of the students filtering through to their own level, but it is axiomatic that sound constructive criticism of our present system requires a knowledge not only of the role which that system should play in our national life, but also of the backdrop — economic, social, political, and spiritual — against which this role is played.

In this slender volume, arising out of the Tulane University Mitchell Lectures, W. C. DeVane, Professor of English and Dean of Yale College, examines the American university as an institution of national importance. He does so by considering its traditional as well as its adopted scope and function, the college on which it is founded, the changing character of its offerings and aims in a period of continuous expansion, and its relation to our national culture and well-being. What he finds, in the main, is good, sound, and worthy of our utmost support. Its greatest danger lies in the possibility that, like so many of our colleges, the university may become merely a reflection of our national life rather than its forward-looking leader.

Like any institution, the university has had and continues to have its evolution. It was, from the beginning, a German educational superstructure welded to an earlier established collegiate base that owes its origin to the English schools. From this hybrid merger have proliferated numerous vigorous offspring which defy categorization, and which today mean many things to many people. As the author states, "Each educational institution, worthy of the name, has its own genius . . . which grew out of the aspirations of the community that produced it." A natural diversity was inevitable and, indeed, desirable. The older universities of the Northeast differ appreciably from the teeming state schools of the Midwest; those of the Far West differ in turn from their sister institutions in the South. As representatives of these regions, they are the "preservers of our culture, the advancers of learning, to some extent the moulders of the ideas and standards we live by, the imperfect arbiters of taste, and the pride of the nation." In this day of educational unrest and upheaval, the university must not only hold to these tasks as never before, it must strengthen its hold with renewed vigor and tenacity. To relinquish its grip is to invite educational disaster at a time when its collective leadership is desperately needed. We have seen the enormous dilution and diversity of effort which has sapped the strength of our precollegiate and even our collegiate systems of education. The author sounds a timely note of warning at the same time that he gives the reader an able historical account of a vitally important institution. As he points out, the university of today assumes a heavy duty: it must, while retaining its traditional functions, "originate the new ideas by which our society and the world must progress." This is a task it cannot lightly dismiss, discharge, or delegate; to do so would be to issue an open invitation to an aggressive professionalism and vocationalism which, however desirable for purposes of immediate practicality, would soon defeat their own ends.

C. P. SWANSON

THE ROAD TO INNER FREEDOM. *The Ethics.* *By Baruch Spinoza; edited and with an introduction by Dagobert D. Runes. Philosophical Library, New York.* $3.00. 215 pp. 1957.

The subtitle of this book is somewhat misleading; the text represents an abridged and rearranged version of R. H. M. Elwes' translation of Spinoza's *Ethics*, with some revisions made in the translation by the editor, a lifelong student of Spinoza. Several of Spinoza's original propositions and many of the proofs are missing entirely; the definitions and axioms are generally omitted also. Spinoza's original elaborate geometrical formulation of the *Ethics* has in fact been reduced to a collection of maxims with relevant short essays. For the general reader, Runes' treatment may serve as an introduction to the general character of Spinoza's ideas, but the more scholarly reader will prefer to approach Spinoza on Spinoza's own terms.

JAMES J. HILL

INSIGHT. *A Study of Human Understanding.* *By Bernard J. F. Lonergan, S. J. Philosophical Library, New York.* $10.00. xxx + 785 pp. 1957.

The only analogy that could perhaps be found to suggest what this book is like would be Ogden and

Richards' *The Meaning of Meaning*, but the present text is far removed from a treatise in semantics. It subsumes semantics, and, although the author protests that his is not an "erudite work," it also subsumes the whole of the history of philosophy, the theories and data of modern and classical physics, biology, mathematics, psychology, and psychiatry. The author, a professor of Dogmatic Theology at the Gregorian University, is something more than an encyclopedic mind, however, for this text is of the nature of a philosophical synthesis undertaken from a moving point of view. The inner logic of the work is, in fact, a process. Lonergan's book is perhaps one of the most ambitious syntheses undertaken in recent philosophy, and has something of the scope of Sheldon's *God and Polarity*.

The first question which poses itself to the prospective reader is, "What is insight?" The author everywhere carefully defines his terms: "By insight . . . is meant not any act of attention or advertence or memory but the supervening act of understanding" (p. 9). By way of example, the author suggests that it is the kind of "organizing intelligence" that solves the ideal detective story once all the clues are available. On a more sophisticated philosophical level, he believes that an elaboration of the nature of insight will "cast into the unity of a single perspective . . . Plato's point in asking how the inquirer recognizes truth when he reaches what, as an inquirer, he did not know . . . what Descartes was struggling to convey in his incomplete *Regulae ad directionem ingenii*, what Kant conceived of as *a priori* synthesis, etc." The author's purpose, then, is to convey an "insight into insight"; to find the underlying and unifying factors in all human knowledge. He begins (where he believes the answer at least in part lies) with a carefully reasoned examination of the scientific method, particularly as it has been utilized in mathematical physics. This procedure occupies the first part of the book; the second part takes up an attempt to demonstrate a realistic metaphysics on the basis of what has preceded.

Lonergan's philosophical position is not susceptible to easy definition. It is a synthesis of considerably broader scope than a purely medieval scholasticism, and seems both oriented toward and profoundly indebted to the philosophical tradition that runs from Plato and St. Augustine through Descartes and Kant; yet for all the idealistic influences, Lonergan remains clearly and fundamentally a realist. His outlook is in some ways reminiscent of that of J. Maréchal.

The author is "sanguine enough to believe" that he has "hit upon a set of ideas of fundamental importance." He believes that there are certain "invariant structures of experiencing, inquiring, and reflecting"; that there is a structure to the knowing and the known — and one considerably different from that which Kant presented. Lonergan writes with humility and lucidity, and his presentation is extremely precise. His book is a long but rewarding experience, but its ultimate contribution to philosophy will perhaps not be fully evaluated for some time. No serious philosopher of science will want to ignore the first part of the book; few serious philosophers will choose to ignore the second.

JAMES J. HILL

LOGIC WITHOUT METAPHYSICS *and Other Studies in the Philosophy of Science.*

By Ernest Nagel. The Free Press, Glencoe. $6.00. xviii + 433 pp. 1957.

This volume, like the earlier *Sovereign Reason* (*Q.R.B.*, 31: 119–120. 1956), is primarily concerned with the philosophy of science, and is likewise comprised of a collection of articles, addresses, and reviews published separately in philosophical journals. The articles cover a wide range in time and topic. The earliest article dates back to 1940, and reading through the collection it becomes apparent that Nagel's thought is not bound by rigid formalisms, but is flexible, dynamic, perhaps even restless as he scrutinizes, examines, and evaluates the phenomena of contemporary science and philosophy. Indeed, he himself confesses in the Introduction that "the earlier essays no longer express my views as I would state them today."

Nevertheless, the philosophical position remains primarily that of a naturalistic pragmatism, or, as the author seems to prefer to call it, a "contextualistic naturalism." Nagel's philosophical position, however, is of secondary significance compared to his contributions to logic, and the light he sheds on the methodologies of science. His success follows naturally from his general approach to philosophy. He resists the temptation to "emulate the great system builders in the history of philosophy. The majority of the best minds among us," he says of the philosophers, "have concentrated on restricted but manageable questions . . . ."

It is this concentration on particular problems and the application to them of a sophisticated analytical philosophy that have made Nagel one of the voices of philosophy listened to most frequently and profitably by scientists, for he is indeed one of the few modern philosophers genuinely familiar with the methodologies of science, and he writes with a rare combination of clarity and technical competence. Few readers will find his carefully reasoned essays unprofitable.

Nevertheless, the broader, more humanistic mind will perhaps remain unsatisfied by Nagel's philosophical outlook, and may take him to task for the very limitation of interest which has made his work so profitable for the philosophy of science. Can it ultimately be maintained, for example, that "no demonstrable ground has yet been found which can guarantee that such regularities [the "regularities" of nature] will continue indefinitely or that the propositions asserting them are necessary"? Does the fact that "no . . . general agreement can be found, even among lifelong students of the

subject, concerning the states of various logical and mathematical principles constantly employed in responsible inquiries, "vitiate the possibility of a valid metaphysics? A naturalistic philosophy which "... professes to accept [solely?] the methods employed by the various empirical sciences for obtaining knowledge about the world" seems ultimately incompatible with any defense of Plotinus against the queasy mysticisms of Aldous Huxley (cf. review of *The Perennial Philosophy*, pp. 389–392). Are final causes really "ancient asylums of ignorance"? Not all scientists have believed so, but Nagel avers that "the philosophies ceremonially professed by most men of science are largely irrelevant to the accredited body of scientific knowledge." If this were true, it would indeed be a sad commentary on human thought in the twentieth century. Nagel seems on sounder ground when he sticks to his "restricted but manageable questions."

JAMES J. HILL

THE IDEALIST TRADITION *from Berkeley to Blanshard. Edited by A. C. Ewing. The Free Press, Glencoe.* $5.50. viii + 369 pp. 1957.

This anthology represents the first of a projected series to be entitled the Library of Philosophical Movements, of which four additional volumes, on Logical Positivism, Realism and Phenomenology, Pragmatism, and Scholasticism, are to appear shortly. The first of the series is extremely promising; as a general introduction to modern idealist philosophy, it would be difficult to find a comparable single text. In the selections, the emphasis is placed on British and American scholars (8 of the 13 philosophers represented are such), rather than on continental Europeans (of whom Fichte and Schelling are excluded). Hegel is represented only by selections from secondary sources rather than from his own writings — perhaps a prudent decision, but it seems difficult to believe that some representative passages from Hegel's own writings could not be found. The omission of Schelling is more serious.

The reason for these omissions is fairly apparent. The general orientation of the selections is toward the present-day philosophical landscape; hence the selections are less pertinent to the history of philosophy or to the history of ideas than to the controversies of contemporary philosophy. By its very nature, however, an anthology cannot fulfill all purposes, and in this text, whatever is lacking in historical perspective is perhaps nearly remedied by the excellent bibliography, which includes not only the definitive editions of the works of those idealists represented in the anthology, but also of those of any significance who are not represented. The bibliography also includes representative commentaries and important articles, chiefly those published in English, pertinent to each of the authors listed. A final section of the book presents selections from 4 modern opponents to idealism.

JAMES J. HILL

THE ORIGINS OF MODERN SCIENCE, 1300–1800. *Revised Edition. By Herbert Butterfield. The Macmillan Company, New York.* $3.00. x + 242 pp. 1957.

The edition of Butterfield's *The Origins of Modern Science* published by Macmillan in 1951 has already been reviewed with approbation by one of the editors of this journal (*Q.R.B.*, 27: 65. 1952). The present edition is about 24 pages longer than the previous edition. The increase in length reflects minor additions and revisions scattered throughout the volume; the organization and the principal features of the argument remain quite the same. As the previous reviewer said, this is an original, unique, and enlightening contribution to the study of the development of scientific thought. Books in hard covers which sell for as little as $3.00 are at present a considerable rarity; the publishers are to be congratulated for making this volume as readily accessible as it deserves to be. Science on some occasions, according to Butterfield, progresses by means of ideas which represent an enlargment of the mind. Every scientist who has not already read this book could profitably enlarge his mind by taking advantage of the issuance of the new edition.

JANE OPPENHEIMER

PRINCIPLES OF MODERN BIOLOGY. *Third Edition. By Douglas Marsland. Henry Holt & Company, New York.* $6.50. viii + 632 pp.; ill. 1957.

The third edition of this book, like its predecessors, emphasizes the essential unity of biology as a science which derives its principles equally from a study of plants and animals. The material is well organized and is presented in an exceptionally lucid fashion.

This edition has been extensively rewritten to incorporate many of the new developments of modern biology. Some of the areas now included are: (1) recent information on the finer structure of mitochondria, grana, cilia, flagella, canaliculi, viruses, etc., as revealed by the electron microscope; (2) clarification, by tracer isotope methods, of the basic patterns of metabolism in cells generally; (3) Krebs cycle and its relations to the metabolism of high-energy phosphate compounds, and of proteins, carbohydrates, and lipids; (4) new approaches to the study of photosynthesis; (5) new concepts regarding the ultimate origin of living matter, as derived from recent experiments on the abiotic syntheses of organic compounds; (6) new concepts relating to the gene and its DNA components; (7) bacterial

transformations and transductions; (8) analysis of the processes of growth and replication among viruses; and (9) genic mechanisms in the control of development. Although these areas of study might seem too advanced for a general introduction to biology, the material is beautifully interwoven with the rest of the text and is clearly presented. Some of this material is included in two new chapters, Pathways of Cellular Metabolism and Genes: Their Nature and Mode of Action.

Two concluding chapters have also been added, on The Plant Kingdom and The Animal Kingdom respectively. These chapters survey the plant and animal phyla, evaluate phylogenetic relationships, and discuss the importance of each group to the other and to man. The book contains many new photographs and several excellent drawings by Jacques Padawer.

In spite of the appearance of other exceptional textbooks of general biology, Marsland's third edition of *Principles of Modern Biology* is still my choice.

SHERWOOD M. REICHARD

DICTIONARY OF SCIENTIFIC TERMS. *Sixth Edition. By J. H. Kenneth. D. Van Nostrand Company, Princeton.* $12.50. xvi + 532 pp. 1957.

This sixth edition of the *Dictionary* has been prepared under the direction of J. H. Kenneth and includes terms occurring in the following biological sciences: botany, zoology, anatomy, cytology, genetics, embryology, and physiology. Some 14,000 words are included with their pronunciation, derivation, and definition. The selection and spelling are essentially British, but some deference has been paid to American usage. While one might wish that certain definitions had been modernized to emphasize current importance and others more carefully edited, by and large the compilation is reasonable and the definitions accurate. A list of abbreviations occurring in biological literature and a list of metric equivalents should increase the usefulness of the dictionary as a reference source.

DAVID W. BISHOP

BIOLOGY: HISTORY AND BIOGRAPHY

WILLIAM HARVEY. *His Life and Times: His Discoveries: His Methods. By Louis Chauvois. Philosophical Library, New York.* $7.50. 271 pp. + 18 pl.; text ill. 1957.

The tercentenary anniversary of the death of William Harvey was celebrated throughout the world of medicine and biology. One exhibition of books and manuscripts illustrating his life and work was arranged by the Royal College of Physicians of London. Through this exhibit opportunity was taken to present K. J. Franklin's new translation of *De motu cordis*, a manuscript *De motu locali animalium* referred to by Harvey, but the existence of which was hitherto unknown, and the Harveian oration by Sir Charles Scarburgh, discovered by Mr. L. M. Payne of the Royal College of Surgeons of London. Learned journals carried articles on the life and letters of Harvey, and the *Journal of the History of Medicine and Allied Sciences* devoted an entire issue (vol. XII, no. 2. April, 1957) to Harvey.

From France there came a new, definitive biography penned by Louis Chauvois, a distinguished physician, medical historian, and latinist. The biography is a true labor of love, Chauvois being so devoted and loyal to his subject that occasionally one wonders whether Harvey was part man and part god. But devotion is not without virtue, and the biographer has made a keen, scholarly analysis of Harvey.

In the foreword Sir Zachary Cope has summed up this biography in an admirably clear and fair statement:

> Dr. Chauvois has carefully read, studied and sifted all available information about Harvey, and has inspected all the memorials of that great man. In addition, as an accomplished scholar, he has very closely studied the Latin texts of Harvey's published writings. Using all these materials with balanced judgment he has produced a lifelike portrait of Harvey the man and Harvey the scientist. He writes with wit and charm, and with an imagination which adds piquancy to the narrative while not going beyond the probabilities of the case. His evaluation of the preliminary forecasting of the circulation of the blood by Servetus, Colombo and Caesalpinus is remarkably clear and just; he gives them all due credit but shows that their work in no way detracts from the major glory which belongs to Harvey.

Chauvois has made a very real contribution, and though embryologists may feel slighted that Harvey's *Exercitationes de generatione animalium* receives relatively little attention, this biography is a significant landmark. It is especially welcome for, in spite of the hundreds of articles and speeches about Harvey which have been printed, the number of complete biographies is very small indeed.

The publishers have presented us with a pleasant format, nice line drawings, well-reproduced plates, and excellent typography. It is a pity that the translator, who did an extremely good job, remains anonymous. Even Chauvois, though he records his gratitude to the English translator in the Preface, has kept the translator's identity from us. A selected bibliography and index are included.

M. C. SHELESNYAK

ON THE UTILITY OF MEDICAL HISTORY. *Monograph 1. Institute on Social and Historial Medicine. New York Academy of Medicine.*

Edited by Iago Galdston. International Universities Press, New York. $2.00 ix + 73 pp. 1957.

This monograph, which begins a new series, represents the proceedings of the first Institute on Social and Historical Medicine held at the New York Academy of Medicine. The first paper, On the Utility of Medical History, is by Iago Galdston, the editor of the volume. George Rosen discusses Purposes and Values of Medical History; Owsei Temkin next presents A Critique of Medical Historiography; and Gregory Zilboorg treats Psychology and Medical History. Then follows Edwin H. Ackerknecht's contribution, On the Teaching of Medical History; and the volume concludes with Paul Schrecker's brilliant essay on Historians, Empiricists, and Prophets. Each of these authors is a scholar and writer of distinction, and the articles are all of high quality.

The history of medicine and science is in a phase of drastic expansion, and it is a rather strange paradox that in an intellectual world, reft by an apparent chasm between the sciences and the humanities, it still fails to effect a synthesis between these. The explanation is partly to be sought in the dilemma of the scientist who lacks time to learn all he needs of his own specialty, and thus seems to have none to spare for what he considers the luxuries of history. But some responsibility may rest also on the historian when, now that the history of science is at last coming into its own as a vigorous independent discipline, he insists too strongly that it retain its independence. Certainly a number of historians who view it as a branch of learning valuable for its light on history are much less concerned with its significance to science itself.

In fact, the utilities of history to science and medicine are so obvious that it should be superfluous to spell them out; and it is an embarrassing commentary on our state of mind that it should be necessary, as it is, to justify its study in a volume bearing such a title as this.

It is interesting that such a strong concerted attempt to develop such a justification should be made by the medical profession, whose immediate problems are practical rather than philosophical. There is however much in history to explain it. Medical men have had always to maintain the historical view. Firstly, medical *prognosis*, as Paul Schrecker points out, depends on correct *diagnosis*, which depends on the development of an adequate *case history*. In addition, medicine has often been self-conscious as to its position among the other sciences, and has frequently considered itself as straddling across to the arts. A number of the present authors emphasize that with its increasing dependence on laboratory instrumentation, medicine is now changing its character; and they see in historical insight a guide which can enable the bewildered practitioner better to understand his new position.

This is an attitude strongly to be applauded, and it is to be hoped that its significance will be appreciated by the members of other scientific professions, who will enjoy reading this book. Its argument does not mean, as George Rosen makes clear, "that historical study leads to omniscience. On the contrary, when properly applied, history provides one with a salutary, critical point of view. The French historian, Louis Halphen, has remarked in this sense that while history does not turn people into skeptics, it does provide a wonderful schooling in prudence."

JANE OPPENHEIMER

HISTORY OF ENTOMOLOGY IN WORLD WAR II. *Pub. 4294.*

By Emory C. Cushing. Smithsonian Institution, Washington, D.C. $2.00. vi + 117 pp. + 9 pl.; text ill. 1957.

The role played by insect-borne diseases in World War II has never been fully appreciated outside of professional circles. The tremendous effort expended by biologists and chemists in developing means of controlling the vectors of these diseases constitutes one of the more fascinating stories of the war. It is unfortunate that this brief history fails to convey the drama of the story and the sense of urgency and tautness that pervaded the entomological effort. The history of this effort is dramatic, but here it appears dull. The discovery and development of DDT, for example, is told matter-of-factly and not even in sufficient detail to allow the reader to appreciate the forces at work in the making of its history.

This book suffers principally from attempting to crowd into 117 pages a story which is much too large and too grand. The story is so abbreviated that it cannot contain sufficient detail to satisfy the professional reader nor enough of the motives and implications of the various events to satisfy the lay reader. It suffers from superficiality and impersonality. While the names of individuals may have no personal significance to the reader, their inclusion lends an intimacy to history which prevents desiccation without sacrificing detail and accuracy. An appraisal of this book can be summed up by the statement that it is a superficial résumé of a subject deserving of more extensive and imaginative treatment.

V. G. DETHIER

ATOMIC ENERGY IN AGRICULTURE.

By William E. Dick. Philosophical Library, New York. $6.00. x + 150 pp. + 16 pl.; text ill. 1957.

This little book is a member of the publisher's *Atoms for Peace* series and consists of a semi-popular account of the use of atomic energy in research in plant breeding, photosynthesis, the mineral nutrition of plants, pest control, forestry, and food preservation. The reader

will not find an account of the advances which have been made in the studies of the metabolism of farm animals by similar methods, or the more strictly chemical and physical aspects of soils research..

The book is distinctly for the well-educated layman and not for the research specialist. Like all efforts at brief summaries of scientific research, it suffers from occasional overstatements, unavoidable complexities, and omissions. Also, like other general accounts of scientific subjects, the further the subject of discussion is from one's own field of study, the better the book becomes. On this basis, while the chapter on plant breeding has some downright exaggerations of fact for plant breeders, it may not appear too bad to the plant physiologist and should prove postively fascinating to the well-educated lawyer.

The author has attempted to correct some of the difficulties in the presentation of his subjects by developing pertinent scientific background, going back in some instances many years. In this the lay reader will be rewarded, for he will gather something of the nature of some of the problems in these fields and how atomic energy is being used to solve them. Since every research specialist should also be a well-educated layman, he too will find the book useful. For this, however, he must pay 4 cents a page.

WALTON C. GREGORY

NUCLEAR ENERGY IN THE SOUTH.

Edited by Redding S. Sugg, Jr. Louisiana State Press, Baton Rouge. $3.50 xv + 151 pp. + 8 pl. 1957.

Since the beginning of the present century, private industry has had to recognize the necessity of coordinating its efforts in development with those of complementary or conflicting governmental functions. For the most part, this has been a gradual and somewhat orderly evolution in the industrial development of our country. However, with the advent of atomic energy and the initial governmental monopoly in its development, the most poignant problem in the economic development of a tremendous energy resource has been encountered. No single individual and few single industries are equipped to shoulder the responsibilities and risks involved in the economic development of nuclear energy.

Nuclear Energy in the South is an account of the tentative efforts of a section of the country, through its state governments, to assist in the transfer of the development of atomic energy from the federal monopoly into the hands of private industry. The book itself is an outgrowth of a series of panel discussions and a culminating work conference on nuclear energy, sponsored by the Southern Governors Conference through the Southern Regional Education Board. It is a résumé of current developments, and of the opportunities and the obstacles in the use of nuclear energy in electric power production, industry, agriculture, medicine and public health, and man power. The development of nuclear energy in power, industry, and agriculture is treated in the first 3 chapters and in 53 pages. It is obvious that no very exhaustive treatment of this vast area could be presented in so short a space. Yet the editor has done a reasonably effective job of outlining the power demands, resources, and nuclear opportunities in the southern region.

The reader may be as surprised by the vacuum of imagined economic opportunity as he is impressed with the research possibilities inherent in the nuclear scene. Whether wilfully or not, the impression is maintained that, even with governmental subsidy and propaganda, use of the atom as a source of energy for general industry is likely to come into being but slowly.

Chapter 4, on nuclear radiation in medicine and public health, has been executed in a highly commendable manner and is the highlight of the book. Although the editor apologizes for this chapter as too technical for the average reader, it is likely to be the most worthwhile reading in the book. The fifth, and last, chapter presents a discussion of the very pertinent problem of educated manpower in engineering and in the physical sciences and mathematics. Statistical tabulations and projections on this subject, both nationwide and with particular reference to the southern United States, point up some of the gaping deficiencies in this field. The assumption appears to be made that the necessary trained manpower can be had merely by increasing the supply of good science teachers of a good science curriculum. In all this it should be pointed out that the proportion of the gifted is most probably not increasing in the population, and that the proportions of men required in other professions and in business enterprises of all kinds are not likely to change radically downward in a society of increasing complexity. The hard fact is that any large increase in science teachers and engineers will likely be made from the ranks of the less gifted, and not from the ranks of persons gifted in the arts of law, medicine, fine arts, or the like.

WALTON C. GREGORY

ECOLOGY AND NATURAL HISTORY

THE TROPICS.

By Edgar Aubert de la Rüe, François Bourlière, and Jean-Paul Harroy. Alfred A. Knopf, New York. $12.50. 208 pp.; ill. 1957.

A more beautiful and exciting book can hardly be imagined. The subject, of course, lends itself naturally to luxurious treatment, but it is not often that authors and bookmakers do as well for their subject as de la Rüe, Bourlière, Harroy, and Knopf have done in this volume on the tropics. On all counts this is a superb

book. It is a breath-taking survey of the great tropical regions of the entire world. De la Rüe has contributed the first two chapters which treat the tropical environment and the plant landscapes of the tropics. Included in these chapters are descriptions of climates, soils, plant communities, the rain forest, climbing plants and epiphytes, the secondary forest, the subtropical forest, palm trees, aquatic vegetation, savannahs, the dry deciduous forest, desert and steppe vegetation, and montane flora. Bourlière has contributed the chapter on animal life in the tropics. Harroy has contributed the chapter on man and the tropical environment. There are 80 photogravure plates, 16 superb colored plates, 34 equally superb colored photographs, and numerous text illustrations. The colored illustrations capture most realistically the surfeit of strident color which characterizes the tropics. One cannot help but be tremendously enthusiastic about this volume on the basis of its illustrations alone. Yet the text is fully equal to the pictures. The authors have done a magnificent piece of work in condensing into limited space an account of the tropics which is at once comprehensive and detailed. For those who have been to the tropics this book brings an overwhelming nostalgia; for those who have never had the good fortune to visit the tropics, it beckons most enticingly.

V. G. Dethier

Chemical Aspects of Ecology in Relation to Agriculture. *Research Monogr. 1; Publ. 1015.*

By Hubert Martin. Science Service, Canada Department of Agriculture, London, Ont. $3.00. 96 pp.; ill. 1957.

Quantitative Plant Ecology.

By P. Greig-Smith. Academic Press, New York. $6.00. ix + 198 pp.; ill. 1957.

As pointed out in the Preface of this handy textbook, change from a qualitative to a quantitative approach is characteristic of the development of any branch of science. European ecology long ago shifted in this way mainly toward sociological studies by aid of quantitative evaluations of the frequency of different components of the community, whereas many American ecologists still are trying to find the most appropriate methods of investigation. The present approach is somewhere between, and it is very likely to become influential among those ecologists who want to improve the exactness and mathematical background of their descriptions and explanations.

The book is divided into 7 chapters, and in addition there are appendices with meteorological data, information on the area and spread of species, tables, references, and subject and author indices. The quantitative methods available for the description of vegetation are discussed in the first chapter, and the next chapter goes into greater detail about these methods and compares the results of different kinds of observations. The significance of pattern, or of the departure of randomness of distribution of individuals within the community, is taken up in the third chapter, and a hypothesis is developed, leading to a consideration of the techniques of detection and an analysis of such designs. This is considered from the aspect of the relationship between patterns of different species in the fourth chapter, which also deals with more details of association; while the fifth chapter studies correlation between vegetation and the habitat factors. The sixth chapter is concerned with plant communities, their delineation and assessment of difference between vegetation stands. In this and the last chapter the classification of vegetation is discussed, and the belief of the author "that the quantitative approach has its own distinctive contribution to make to ecological theory" seems to be strongly substantiated by his many well-worked examples.

This is not a textbook for beginners, but it is certainly a very valuable handbook for advanced students and for ecologists with an interest in an exact quantitative analysis of plant communities. It may perhaps require more than the usual knowledge of mathematics and biological statistics, a knowledge which has long been more prevalent among European than American biologists; but even for those ecologists who are not well acquainted with statistical methods the book has many valuable ideas and suggestions. By reading the text and working through some of the examples, one is convinced that the inclusion within modern ecology of the mathematical approach would greatly increase the exactness of many studies, and would enhance the biological and evolutionary significance of this important subject itself.

Askell Löve

Plant Ecology. *Methuen's Monographs on Biological Subjects.*

By William Leach. Methuen & Company, London; John Wiley & Sons, New York. $2.00. vii + 106 pp.; ill. 1957.

This booklet by the professor of physiological botany at the University of Manitoba from 1937 to 1954 was originally published in 1933 as "a concise account of the aims and principles of Plant Ecology and to serve as a guide to the carrying out of field work in a scientific manner." The first part of this objective may have been reasonably well served by the book, while it always was too sketchy for its latter part. However, the fact that the book was reprinted twice seems to indicate that it has been used by many.

The fourth edition, according to the Preface, has been "completely revised and certain sections have been rewritten and enlarged." That this is an overstatement of unusual magnitude is easily seen in all the chapters of the book, though perhaps nowhere so clearly

as in the last chapter on the history of British vegetation. In that chapter two references are given to Erdtman's preliminary work from 1928 or 1929 (only the latter year in the short reference list), but no mention is made of all the many and thorough papers by British botanists in recent years—Godwin's excellent and comprehensive book on the subject was printed at about the same time as this edition of Leach's booklet. The short list of references includes only two more recent papers, Tansley 1939, and Olsen (not Oslen!) 1936, the former on British vegetation, the latter on manganese absorption, a special interest of the physiologist author. As a whole, the so-called new edition shows no contact with recent ecological literature and could as well have been revised before Leach left England, since there is no evidence to indicate that he has ever seen the Canadian prairies.

This booklet on ecology may perhaps serve well as an introduction for those students in the British Isles who want to know what the principles of old-fashioned ecology were, without spending more than one or two evenings for this study. It may also be useable for high school teachers, and even high school students, as some kind of an orientation of the subject as it was long ago. But it has no message whatsoever for American or Canadian botany students, who can get much more detailed and reliable information about the vegetation of this continent from several other good textbooks written by ecologists who have studied the plant life in North America.

ASKELL LÖVE

THE STUDY OF PLANT COMMUNITIES. *Second Edition. By Henry J. Oosting. W. H. Freeman & Company, San Francisco.* $6.00. viii + 440 pp.; ill. 1956.

This is a new edition of a very useful and stimulating textbook. Oosting's clear expressions and informative pictures have interested many new ecologists during the past ten years, and it is not astonishing that a new edition was needed so soon. There are only a few changes in the text and its arrangement, and additions have been made to bring the material up to date. A welcome addition in literature references certainly increases the usefulness of the book, especially for those who do not have a complete ecological library or who are not in the position to follow the recent flow in ecological publications. It is certainly an advantage for American students that American publications are cited in preference to foreign, although foreign readers of the book might also like to see references to some of the basic publications of the great European ecological and phytosociological literature. The book is of such quality that it can be expected to be increasingly used as a basic text even outside this continent.

ASKELL LÖVE

EVOLUTION

THE EVOLUTION OF HUMAN NATURE. *By C. Judson Herrick. University of Texas Press, Austin; with the assistance of the Dan Danciger Fund.* $7.50. x + 506 pp. 1957.

This book is the result of more than 60 years of intensive study of the evolution of the nervous system by C. Judson Herrick, Professor Emeritus of Neurology at the University of Chicago. Students familiar with this field are aware that Herrick, with his brother, the late C. L. Herrick, spearheaded a movement in psychobiology with little assistance from others. These activities resulted in the founding of a scholarly publication, *The Journal of Comparative Neurology and Psychology* (now simply *The Journal of Comparative Neurology*), of which Herrick is still an editor. These outstanding scientists were also responsible for bringing into the field exceptionally gifted students, among them the late George Ellet Coghill.

In this early American scene, the ferment generated by such leaders brewed a new behavioral psychology based upon a naturalistic approach with less and less emphasis upon metaphysics. Herrick has now, in this exceedingly well-integrated treatise, built a firm base which portrays in detailed clarity what has been accomplished in comparative neurology, psychology, and sociology. Even more significantly, this base is one from which new directions point toward more exciting scientific experimentation and research. "To understand human nature and so learn to control behavior for our own good, each of these components of experience—the objective and the subjective—must be examined separately and in their reciprocal relationships. Such an examination is the theme of this book."

By some persons, this work will be seen as a system of philosophy, by others as a plan for human engineering. Still many others will accept it with the renewed faith that through education much can be done to better ourselves, in agreement with the statement in the Epilogue, that "the Universe is dynamic and *intrinsically creative* at all levels of organization" [italics added]. All three of these approaches are valid. Probably the last is more in keeping with the main theme of the book.

C. J. Herrick is a mechanist, in a broad naturalistic sense. His chapter on The Spiritual Life of a Mechanist indicates clearly his naturalism, but the last two sentences of the epilogue summarize the attitude of mind one may attain if one will only "know." "We are citizens of the Universe. . . . The native creativity is amplified in the domain of organic evolution and glorified when aware of itself in human purposive planning. The sublimity of this conception of man's place in nature commands our reverence and our utmost effort to meet the demands imposed upon us by that nature which is our alma mater."

The book is divided into two parts: Part I, The Evolution of Behavior—Biological Factors of Psycho-

biology; Part II, The Evolution of Brains—Neurological Factors of Psychobiology. Principles of psychobiology are discussed in both parts with due emphasis and interrelated treatment.

Since intrinsic (i.e. genetic, innate) factors basically determine behavior because of their integrative mechanisms, a more detailed account of them is presented, especially as regards the work of Coghill in his embryology of behavior. The external (analytical) factors are treated adequately in chapters 3–6. Considerable space is devoted to such topics as methods of study, the world we live in, and mechanisms of living, including human engineering. Here one finds clearly defined what is natural, mechanistic, and vitalistic. Herrick does not deviate very far from Santayana's definition of nature: "The sum total of things potentially observable, some observed actually, others iterpolated hypothetically."

Two of the most significant chapters in the first section are those which deal with Patterns of Behavior and Analytic and Integrative Factors of Behavior. These vividly portray and enhance Coghill's contribution to the problem of the embryonic development of behavior. Here it is pointed out that discrete (analytic) movements (reflexes) are individuated out of a total pattern (integrative) of behavior. In my opinion, this conclusion has far-reaching significance, in that the natural (innate) origin of conflict arises in this fundamental release of partial patterns from the total pattern. This may apply equally well to society and to the single organism. That is, basically, the welfare of the group, an integrative pattern, releases naturally the individual's behavior, which is analytic in form. Any discrete activity must always be under the dominance of the whole, otherwise harmful (pathologic) effects may arise. The rest of this section is devoted to an elaboration of how things (man included) have evolved, and of necessity concerns the origin of society and the self in reaching the organizational levels discussed. This sober account points to the methods available for guidance in our "progressive" evolution and is optimistic in tone.

The second part of this fascinating book admirably spells out the evolution of the nervous system through which its two major properties, the integrative and analytic activities, mount to their highest manifestation in man. Fundamental nervous functions which are known to most biologists are highlighted in a newer concept, psychophysics, in which the integrated (innate, genetic, neuronal matrix) space-time complex is shown to be a key factor in psychogenesis. "From this starting point separate dimensions of space and time are individuated in the analytic series of sensorimotor reactions." From this standpoint the "body-mind" concept becomes a statement of what mind is. "Mind is here defined as awareness." It no longer is a dual "body-mind," but mind is the body in action. Mind is not the product of the body in the same sense as the secretion of the stomach is the product of that organ. Mind is "a peculiar pattern of action of a special kind of bodily apparatus, just as walking is another pattern of action of a different kind of apparatus." And, it is a special kind of pattern owing to its peculiar level of organization. Herrick concludes, then, from a vast store of accumulated information on the evolution of the brain, that "because no mental abilities can be acquired by the individual except those for which adequate bodily organs are provided in the genetic organization of the species, the evolution of mentation is of more fundamental significance for psychogenesis than its embryological development."

Chapters 26–28 discuss the important topics of sensation, perception, and learning and intelligence, respectively. Also briefly presented in the next four chapters is an account of the evolution, structure, function, and localization of the cerebral cortex of man. The chapter on Mechanisms of Mentation deals largely with the role of the cortex in the itegrative-analytic procedures. The projection areas are analytic; the rest of the cortex (probably aided greatly by the reticular formation of the brain stem) is integrative.

The final chapter is a review of the integrative-analytic relationship as applied to mind and the dimensions of the mind. Coghill's concept of mind as a "total pattern of integrative type" is maintained, but Herrick goes far beyond Coghill.

"Coghill's program of research led to the conclusion that mentation is a total pattern of integrative type, and some of the properties of mentation, as we experience it subjectively, he was able to recognize behavioristically in all other animals. He sharply distinguished the integrative processes from the analytic functions (which he called 'organismic'). I go further and maintain that this distinction is manifest in all natural processes, both inorganic and vital, and that we recognize various levels of integration which are defined in terms of the patterns of performance. The distinctive characteristics of integration as I describe them (Chapter 8) reach their highest development in human rational thinking. All integrative processes are directive. At every step from lower to higher levels something new is added. The higher patterns are not made by simple additive assembly of the properties of the lower, and the laws of their operation are not identical with those of the lower. This is as true of a chemical reaction as of the creative imagination of a philosopher or a poet."

PAUL G. ROOFE

DIE EVOLUTION DER ORGANISMEN. *Ergebnisse und Probleme der Abstammungslehre. Second Edition. Lf. 5.*

Edited by Gerhard Heberer. Gustav Fischer Verlag,

Stuttgart. DM 18.50 (paper). iv + pp. 857–1109; ill. 1957.

The first 4 Lieferungen of this valuable work were previously reviewed in this journal (*Q.R.B.*, 31: 44. 1956). The sixth, announced but not yet received, will complete the work with articles by Roche and Lehmann on human racial genetics and by von Eickstedt on the evolution of mentality, plus an index for all parts. In the present Lieferung the general editor, G. Heberer, writes on additive typogenesis, von Krogh on the place of the hominids among the primates, and Gieseler on the fossil history of mankind.

By a "type" Heberer (following Zimmermann) means "a systematic unit and its characteristics." "Additive typogenesis" is the origin of such types (i.e., of taxa and their distinctive features) by the summation of small changes. Heberer holds that the small changes originate as ordinary genetic mutations (in the broadest sense) and recombinations, and that their summation occurs under the influence of natural selection in populations. He is, in short, a strong and persuasive adherent of the synthetic theory of evolution essentially as also expounded by Huxley, Dobzhansky, this reviewer (as Heberer emphasizes), and others. Heberer's purpose here is not so much to expound the general theory as to show that the origin of taxa from species upward is in fact by summation in populations and not by individual systemic mutations or saltations. Schindewolf is the leading exponent of the latter view, and Heberer is at special pains to refute him. I, at least, am satisfied that the refutation is successful. It is somewhat confusing that both Heberer and Schindewolf apply the term "typogenesis" to their radically different theories of the origin of species and higher taxa. In all other respects Heberer's is an almost ideally clear and dispassionate exposition of a series of exceptionally intricate related problems.

Von Krogh's comparatively short chapter (34 pp.) is an adequate review of the now overwhelming evidence that among living primates man most nearly resembles the African pongids: the gorilla and chimpanzee, especially the latter. He interprets the resemblance as truly genetic and believes that man and chimpanzee had a common ancestor among Miocene dryopithecines. (The Miocene or other fossil apes are not, however, specially discussed in the present work.)

Most of Gieseler's long (159 pp.) contribution is a careful and useful summary of all Old World fossil hominids considered older than Aurignacian on the European scale. As is now usual, in spite of some holdouts, he includes the australopithecines among the hominids. The ground has often been covered before (notably in the classic *Les Hommes Fossiles* by Boule and Vallois, 4th edition, 1952), and Gieseler has only a few later discoveries to add. Arambourg's recent discovery of a pithecanthropoid in North Africa is included, but unfortunately the discovery of a jaw and other remains of *Gigantopithecus* in China is not. Had the latter announcement reached Gieseler in time he could have omitted the rather lengthy argument as to whether *Gigantopithecus* is a hominid: it is not. Gieseler was properly skeptical on that point, as he is also on the still far from settled dispute as to possible hominid relationships of the much older *Oreopithecus*. Gieseler's organization of his materials is peculiar. He proceeds primarily in the sequence of discovery dates of the various kinds of fossil hominids and secondarily in the order of their age, from youngest to oldest. For this and other reasons it is not easy to get a really clear over-all view of the significance of the now very numerous and highly diverse finds. It does seem that the time for a lucid synthesis has come.

Misprints in this fascicle are fairly numerous and may especially bother some non-German readers.

Continuation of this great compendium is most welcome. Its completion should soon occur, and even now it stands as a major and truly indispensable work in the whole field of evolution.

G. G. SIMPSON

THE LIASSIC THERAPSID *OLIGOKYPHUS*.

By Walter Georg Kühne. British Museum (Natural History), London. £4. x + 149 pp. + 12 pl.; text ill. 1956.

A curator at the British Museum has told me of a visit, a year or so before the outbreak of the last war, from a young German paleontologist who said that he had come to England to make a living by finding new materials of fossil vertebrates. My friend pointed out to him that this was quite impractical; all English fossil deposits were well known and it was absurd to dream of making major new discoveries. Within the year, however, he found, with pleasure rather than chagrin, that his prediction had been quite erroneous. His young visitor, Kühne, had gone to the west of England and initiated a field of work in the recovery of Mesozoic reptile and mammal remains from limestone fissure fillings that is still being actively pursued by British paleontologists.

Kühne's own finds were mainly of a small mammal-like reptile, *Oligokyphus*. War conditions presently made necessary his internment on the Isle of Man. This was not, however, all lost time; through the friendly aid of the police and the interest of British scientists, Kühne was able to continue work while interned, and indeed, published one preliminary paper during this period. Before the war's end he was released for further study of his fossils at University College, London. A few years later, mimeograph copies of a first draft of part of his studies were circulated among interested workers. The British Museum is to be congratulated on publishing this full and well-illustrated account of Kühne's important material. Of especial interest is the fact that the plates are stereoscopic

photographs, giving the reader a much better knowledge of the specimens illustrated than could be obtained from the best of drawings or single photographs.

The better part of a century ago there was discovered in the late Triassic beds of South Africa a fragmentary skull named *Tritylodon*. Its dentition was of a highly specialized nature; other features made it doubtful whether we were dealing with an advanced reptile or a primitive mammal. A few isolated teeth from the Rhaeto-Liassic of Europe, to some of which the generic name *Oligokyphus* had been applied, appeared to be similar in nature. But apart from later finds of a few more skull and jaw fragments of *Tritylodon*, no further remains of any forms of this sort were unearthed for many decades.

Kühne's fissure finds included a host of bones of the little tritylodont *Oligokyphus*. All were isolated elements, but painstaking work has enabled him to reconstruct, with a high degree of probability, the entire skull structure and, although with less certainty, the whole skeleton. *Oligokyphus* was a small animal—only about a foot and a half long, including a well-developed tail. The legs were absurdly short in their proportions, and the skull, some 3 inches in length, was massively built. The animal, with chisel-like front teeth and a cheek battery of multicuspid "molars," was obviously a herbivore. The teeth resemble in some ways those of the ancient mammals termed the Multituberculata, and the tritylodonts were long thought to belong to that group. The sum total of the anatomical features show, however, that *Oligokyphus* was technically a reptile. But it was a very advanced one. Apart from the diagnostic mammalian shift in jaw articulation and correlated middle ear structures, the tritylodonts show nearly all the mammalian features found in the living monotremes. They are themselves too specialized to be mammal ancestors, but illustrate in many ways the stage through which their pro-mammalian relatives must have been passing in late Triassic times.

As said, the tritylodonts were long a very obscure group. The situation is now changing rapidly, and not entirely due to Kühne's work. At about the same time that he worked in the Mendip Hills of England, the Chinese paleontologist C. C. Young discovered remains of another tritylodont, *Bienotherium*, in Yunnan; and within the last few years, numerous remains of still another member of the group have been found in northern Arizona; these are currently being studied by G. E. Lewis and E. H. Colbert. From being the most obscure, the tritylodonts may presently prove to be one of the most adequately known of mammal-like reptile types.

ALFRED S. ROMER

THE OLIGOCENE FLORA OF THE BOVEY TRACEY LAKE BASIN, DEVONSHIRE. *Bull. Brit. Mus. (nat. Hist.), Vol. 3, No. 3.*

By M. E. J. Chandler. The British Museum (Natural History). 25s. (paper) Pp. 71–123 + pl. 11–17; text ill. 1957.

THE EVOLUTION AND SYSTEMATICS OF THE IGUANID GENUS *UMA* AND ITS RELATION TO THE EVOLUTION OF OTHER NORTH AMERICAN DESERT REPTILES. *Bull. Amer. Mus. nat. Hist., Vol. 114, Art. 3.*

By Kenneth Stafford Norris. American Museum of Natural History, New York. $1.50 (paper). Pp. 247–326 + pl. 43–46; text ill. 1958.

EVOLUTIONARY TRENDS IN THE CLASSIFICATION OF CAPITATE HYDROIDS AND MEDUSAE. *Bull. Brit. Mus. (nat. Hist.), Zool., Vol. 4, No. 9.*

By W. J. Reese. British Museum (Natural History), London. 25s. (paper). Pp. 453–534 + 2 pl.; text ill. 1957.

In an attempt to replace the usual dual system of classification of hydroids and medusae, these two coelenterate forms are here for the first time integrated into one classification. This is, therefore, an important article for students of coelenterates. Advances in the knowledge of capitate hydroids have enabled the author to eliminate here the old dual system. Contrary to usual views, the large solitary corymorphid types are considered the most primitive, with a basic pattern of two whorls of tentacles, primitively moniliform. The shorter capitate type of tentacle is regarded as a later development of the distal whorl. The hydroid *Euphysa* is regarded as a basic type from which several evolutionary lines can be traced There are considered to be three main evolutionary lines: the *Corymorpha-Tubularia-Margelopsis* line, with large polyps and complex internal structure; the *Acaulis-Myriothela* line, with scattered capitate tentacles; and the corynoid line, forming colonies with small hydranths and only one tentacular circlet, the distal one.

The medusae of capitate hydroids are regarded as the most primitive hydromedusae with deep bell, four tentacles with moniliform batteries, and four radial canals. The free medusa is an independent organism, evolving along its own lines.

As regards the origin of alternation of generations, the actinula-medusa theory is accepted. The actinula persists in the more primitive families of capitate hydroids. The primitive cycle had no alternation of generations, but the actinula developed directly into a primitive medusa of the trachyline type, and the hydroid generation was the result of budding in the actinula stage. The author inclines to the view that the Hydrozoa are medusoid in origin and that the hydroid phase is a later development. Once established, however, the hydroid phase may become the dominant one to the eventual exclusion of the medusa, as in advanced hydroids of such families as the Sertulariidae and Plumulariidae. The trend toward elimination of the medusa phase is apparent at all levels of hydroid evolu-

tion. Stress is laid on the mosaic patterns in Hydrozoa, a bleeding of the characters of hydroids and medusae into a pattern that gives a much better picture of the species as a whole. A number of species are considered in detail to illustrate mosaic patterns.

In the scheme of classification Capitata is made a suborder of the order Anthomedusae and is subdivided into four superfamilies: Tubularoidea, for *Corymorpha*, *Tubularia*, and the like; Tricyclusoidea for the peculiar species *Tricyclusa singularis*; Acauloidea for *Acaulis*, *Myriothela*, and the like; and Corynoidea for the ordinary colonial forms as *Coryne*, *Cladonema*, *Halocordyle* (=*Pennaria*) and related forms

L. H. HYMAN

GENETICS AND CYTOLOGY

THE CHEMICAL BASIS OF HEREDITY. *A Symposium sponsored by the McCollum-Pratt Institute of the Johns Hopkins University.*

Edited by William D. McElroy and Bentley Glass. The Johns Hopkins Press, Baltimore. $12.50. xi + 848 pp.; ill. 1957.

This book contains the proceedings of the largest of several symposia held in the United States during the spring of 1956 on the general topic of the chemical aspects of heredity. Since the book is by now well-known to workers in chemical genetics, for whom it is required reading, this review is intended primarily for interested onlookers.

The symposium consists of 37 papers ranging widely, but not very systematically, over the field of modern genetics, from classical chromosome cytology to the stereochemistry of nucleic acid molecules. The treatment is as heterogeneous as the subject matter. Some papers are extensive reviews, while others are reports, sometimes very brief, of work in progress. A high percentage of the papers are works of genuine value and even distinction; but the symposium has its share of the usual potboilers, too. Almost none of it can be recommended to beginners.

Of the major groups of papers into which the symposium seems to fall, the most important is that dealing with the chemistry of nucleic acids. These papers, comprising about half the symposium, bear witness to the impact on genetics of the discovery that nucleic acids—not proteins, or even nucleoproteins—constitute the genetic material of certain bacteria and viruses. Everything pertaining to their structure, metabolism, and function is now of potential genetic interest.

In one of the notable contributions to the symposium, Kornberg described the net synthesis of DNA in an apparently simple cell-free system obtained from *E. coli*. That actual duplication of DNA may be taking place in the system, rather than random polymerization of nucleotides, is suggested by the fact that all four of the nucleotide building blocks must be present for the reaction to go, and a primer of preformed DNA must be added. The Watson-Crick structure of DNA, whose genetic interest stems from the fact that it suggests a molecular basis for gene duplication and mutation, was the target of the usual playful epithets from the organic chemists present, but no one suggested that the structure is incorrect; on the contrary, it seems more firmly established than ever. Replication of the Watson-Crick structure does not appear to be a straightforward matter, however, owing to the plectonemic (intertwined) coiling of its two stands. Delbrück and Stent systematically discussed possible solutions of this difficulty. A hint that the solution may actually be a simple one is contained in Rich's finding that mixtures of synthetic polyribonucleotides can spontaneously form two-stranded helices in solution. These synthetic polyribonucleotides resemble natural RNA and DNA in configuration (Watson). The question of intermediates in DNA replication was taken up by several authors. Volkin and Astrachan presented evidence indicating that RNA may mediate in phage DNA synthesis, and Delbrück and Stent referred to data which suggest that the genetic information contained in phage DNA may be stored in a phosphorus-free material (e.g., protein) during the early stages of phage development. Interesting physical studies on bacterial transforming principles were reported by Ephrussi-Taylor, Zamenhof, and others.

A smaller group of papers deals with the genetics of various microorganisms, including viruses. It is conventional to regard microbial genetics as a branch of the chemical study of heredity, as if all genetic phenomena in microorganisms were readily interpretable in molecular terms. This, in fact, is not the case. Bacterial genetics, for example, is in most ways more obscure than the genetics of *Drosophila*; and, indeed, a detailed account of the concepts of crossing over, position effect, and pseudoallelism, as they have been developed in *Drosophila*, would have benefited the subsequent discussion of possibly similar phenomena in bacteria and viruses. Beadle's concise sketch of these notions of "classical" genetics, given in the opening paper of the symposium, is admirably clear, but, in the context of the whole proceedings, all too brief. Among the interesting or important papers in this group is a 50-page monograph by Hartman on transduction, a process of genetic exchange peculiar to certain bacteria. The growth rate of bacterial genetics can be judged by the fact that although transduction had been known for only 5 years at the time, Hartman was able to assemble a bibliography of 335 references.

A third large group of papers deals with various aspects of cellular organization and with gene action, including protein synthesis. A long review of chromosome structure by Ris is of value despite (in some ways, because of) the fact that it has been dated by the important tritium-labelling experiments of J. H. Taylor and coworkers, which were published while this volume was still in press. The papers dealing with gene action

present a heterogeneous assortment. Although a number of them are of interest to the specialist, they do not give a balanced picture of the field. Here, too, recent findings—especially those of V. Ingram on the structure of mutant human hemoglobins—have spectacularly dated many previous discussions.

A useful summary of the entire symposium, by Glass, concludes the volume. A spot check of the indexes revealed gaps.

N. H. Horowitz

Cytology and Cytogenetics.
By Carl P. Swanson. Prentice-Hall, Englewood Cliffs. $10.00. x + 596 pp.; ill. 1957.

Cytology is not an old science but one which is growing very rapidly and making an increasingly greater impact on other biological sciences because of its importance for the understanding of the laws of evolution. For a long time its development was slow and somewhat hampered by the lack of a general hypothesis, which would explain various disconnected observations. Such a hypothesis was furnished by Darlington in 1931 and 1937 in his tremendous contribution, the classical work *Recent Advances in Cytology*. This book, which has been like a Bible for cytologists for more than twenty years, has been out of print for a long time, and none of the many cytogenetics textbooks published in different languages since its last revision has been at such a level that it could replace this fundamental text. Only in the great new *Allgemeine Pflanzenkaryologie* by Tischler has a reference book to more recent cytological discoveries been available, but its size and language (it must be acknowledged that only a few cytologists in America understand German sufficiently) make it less useable for the majority.

The need for a comprehensive textbook and reference book at a high level has consequently been keenly felt for many years. This requirement was met early last year in a splendid new book written by Swanson, one of the leading authorities in studies of the effects of radiation on chromosomes and at the same time a broad-minded cytologist of the most modern kind. His most welcome book bears a worthy dedication to Karl and Hally Sax, the great cytological team of the Arnold Arboretum. It is not written in the brilliant and thrilling style Darlington alone seems capable of using in cytological writing, but it is a clear and concise report of observations and hypotheses every student can easily understand. Swanson's *Cytology and Cytogenetics* is, indeed, a catching and well-written book many cytologists will use with the same enthusiasm and delight as former generations used the *Recent Advances*.

During the past twenty years much as been added to our knowledge of the cell and its constituents, and many hypotheses have been discarded or strengthened. Swanson spends little space repeating historical data, but uses most of his introduction explaining the newer tools and techniques. This is typical also for the long and fundamental chapters on the cell and its divisions, chapters in which the reader gets information not only about the processes of mitosis and meiosis and their most modern explanations, but also on the parts of the cell other than the chromosomes. Explanations of the function, structure, and movements of the chromosomes take up a good deal of the book, and it is especially admirable how well the author has been able to give such a neutral report of these phenomena that the reader does not doubt that all the different explanations may be equally meritorious and equally correct. This point of view is very likely to induce the interested student to find new and better explanations, or to reconcile conflicting hypotheses, as might seem to be necessary for some parts of the hypotheses on chiasmata and crossing over, to mention but one of the many examples from the book itself.

Since cytology has become so large a subject that it has been divided into sections using different methods and approaches, it cannot be expected that any single cytologist is capable of giving an equally comprehensive account of all its subdivisions. The predominantly chemical approach, fundamental for the understanding of basic phenomena, is typical of most American cytologists and is very nicely represented in the book. However, the majority of European cytologists have approached this field of study in a somewhat different way, perhaps thinking more of evolutionary effects of the fundamental observations than of the basic processes themselves. These approaches are occasionally treated somewhat more superficially in the book, as indirectly indicated in its introduction, but the author cannot be blamed for omitting much of the material already available in the now somewhat outdated *Recent Advances*. Thus, polyploidy, which is known to occur in about one-third of all higher plants and which is of an immense evolutionary significance, is treated rather briefly and not always in a very modern way. Important phenomena like sex determination, chromosomal differences and karyotypes, endomitosis and endopolyploidy, apomixis, and B-chromosomes (which are somewhat incorrectly classified with other "supernumeraries"), and several other phenomena studied in great detail by the many European schools of cytologists do not get voluminous treatment. This is a pity, since these phenomena are as much integral parts of cytology as are the cell divisions themselves. If these and other phenomena had been treated in greater detail, a somewhat better balance between the two main directions of cytology would have been achieved in the book. If something more about these and similar phenomena is added in the next edition—there must soon be a need for a second edition of such a textbook—I believe it will add to its usefulness. However, these remarks do

not decrease its value as the best text now available and a worthy successor of the classical *Recent Advances in Cytology*.

The reference list is extensive, counting more than 1000 titles. It is by no means complete, and some of the citations are long outdated and should have been replaced by more recent ones; this, for example, is true of the references to my own work. It would have been advisable to give at least one reference to Tischler's *Pflanzenkaryologie* for those who want more complete information on the cytology of the past up to the very latest times, since nowhere else are more complete references to all subdivisions of cytology available. As is typical of almost all recent American textbooks, American references are over-represented, and citations in languages other than English are almost absent; only about 5% are in other languages: most of them in German; 7 in French; 1 each in Portuguese and Spanish; none in Italian. In the few foreign names and references present there are more printing errors than in the entire text, probably caused by the proofreader's ignorance but sometimes due to the fact that the originals were not consulted, as in the only reference to Tischler (which, by the way, does *not* discuss polyploidy in algae and bryophytes, as stated on p. 503, but only gives references to studies on chromosome numbers from the higher plants of Central Europe!). But these are punctilious remarks on matters which hardly affect the general quality of the textbook, even if they may become annoying to those who use its reference citations without looking them up themselves!

Swanson's *Cytology and Cytogenetics* is a book one would like to recommend not only to all students of this important science, but also to experienced cytologists who may perhaps have become a little rusty in some of the classical details or who have had difficulties in following the many recent advances made in the different branches of their subject. The book is not only stimulating to study but also attractively printed and filled with very informative illustrations which make its reading as pleasant as it is educational.

ASKELL LÖVE

THE PRINCIPLES OF HEREDITY. *Fifth Edition.*
By Laurence H. Snyder and Paul R. David. D. C. Heath and Co., Boston. $6.25. xi + 507 pp. + 6 pl.; text ill. 1957.

The fifth edition of *The Principles of Heredity* by Snyder and David, retains the clear expository style of former editions (by Snyder alone) and brings the teacher and student up-to-date in the current advances in genetics. An advantage of this textbook in the past, and one which has been retained in the present edition, is its general coverage of the genetics of human beings, lower animals, and plants. This wide application of the principles of heredity extends to the excellent problems found at the close of each chapter. The new material in this edition includes a discussion of psuedoallelism, advances in biochemical genetics, gene function, a review of present knowledge of the chemical nature of the gene material, and a chapter on bacterial genetics. Paul David has been chiefly responsible for the excellent revision and expansion of the consideration of eugenics. Both teacher and student will appreciate the excellent diagrams and photographs.

SARAH B. PIPKIN

MITOTIC POISONS AND THE CANCER PROBLEM.
By John J. Biesele. Elsevier Publishing Company, Amsterdam, Houston, London, and New York. $7.50. viii + 214 pp.; ill. 1958.

The term "mitotic poison" is defined by Biesele as "any agent affecting mitosis, whether during or following treatment." This review treats of the mechanism of action of such poisons with respect to the structure and physiology of cells and the implications in cancer therapy. The body of the book consists of 3 extensive chapters: Poisoning in Prophase and Earlier Stages; Poisoning of the Chromosomes; and The Poisoning of Metaphase and Later Stages. The emphasis is effectively placed on the metabolic aspects of the cell by an examination of the most recent research and the myriad compounds whose effects have been investigated. The chapters on chromosome and metaphase poisoning are especially well done and thorough. This is an excellent reference book as a result of the concise, lucid treatment of such voluminous information and the complete reference list of 22 pages. It should prove an invaluable aid to persons whose interests lie in these areas.

NORMAN S. COHN

GENETICS. *Revised Edition.*
By Edgar Altenburg. Henry Holt & Company, New York. $6.50. xv + 496 pp.; ill. 1957.

This newly revised textbook will prove highly stimulating to the user. The detail with which the author presents his chapters on Biochemical Genetics and The Genetics of Bacteria, Yeasts, and Viruses is especially commendable. The space devoted to them is fully justified. These chapters are recommended not only for the student but also for bacteriologists and virologists who are interested in a classical geneticist's views of their field.

One should be cautious in accepting the diploid chromosome number in humans as always 46, since chromosomal polymorphism may exist in the species (Kodani). In any case, the author should be consistent. On p. 5 we read that the diploid chromosome number in man is 46 and the haploid number, 24, numbers sure

to be challenged by the student, especially as Painter's drawings of 48 chromosomes appear on p. 97. This is a small point, important only because the organism discussed is man.

References and excellent problems for the student are to be found at the end of each chapter. Illustrations are fully adequate.

SARAH B. PIPKIN

THE PHYSICAL AND CHEMICAL BASIS OF INHERITANCE. *Condon Lectures.*

By G. W. Beadle. Oregon State System of Higher Education, Eugene. $1.00. 47 pp. 1957.

GENERAL AND SYSTEMATIC BOTANY

INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE *adopted by the Eighth International Botanical Congress, Paris, July, 1954.*

Edited by J. Lanjouw and Committee. International Bureau for Plant Taxonomy and Nomenclature of the International Association for Plant Taxonomy, Utrecht. $7.00 (free to Institute Members I.A.P.T.; $3.50 to Regular Personal Members). 338 pp. 1956.

It is a long road from the poet Henry van Dyke's quip that "naming things is one of the oldest and simplest of human pastimes" to this 338-page *International Code of Botanical Nomenclature*, by which the professional taxonomist must triangulate his new species. The *Code's* Preamble states that "botany requires a precise and simple system of nomenclature used by botanists in all countries," dealing with terms and names. That a name is a "means of referring" to a taxonomic group is *the* purpose of giving a name. Rules are instituted among botanists to remove ambiguity, confusion, or duplication of names. After rules are instituted there stands the motto of the House of Orange, *Je maintiendrai*—let there be stability.

This botanical code is a model of completeness, and the contents are made accessible by an admirable index. The text is reproduced in four languages, English, French, German, and Spanish, followed by five appendices, the most important being the taxonomic register of conserved names. The useful Appendix IV on the Determination of Types particularly stresses the application of the term "lectotype."

S. F. Blake has remarked that "Linnaeus was the greatest name-shifter," although he gathered no statistics. Linnaeus misapplied names of the Greek and Latin authors, whether or not they applied to the same plant, in preference to keeping the names bestowed by his contemporaries. Henceforth, the "only proper reasons for changing a name are either a more profound knowledge of the facts resulting from adequate taxonomic study, or the necessity of giving up a nomenclature that is contrary to the rules." "Successful nomenclature," Weatherby writes, "is a matter of common consent." Optimist that he was, Weatherby was more impressed by the success of the basic procedures rendered concrete by custom and finally coded by DeCandolle than he was by vagaries of their application. The *Code* is now "almost as durable as the Linnaean scheme itself," and this edition contains no drastic changes. One new term, already misused when applied to a unit in population genetics rather than retained for the nomenclatural purposes for which it was proposed, is the word *taxon* (plural, *taxa*). To be commended is the use of the repetitive subspecific name, when a species is divided, for that portion of the species population which must rest upon the original type. There has been some opposition to this practice, which has been stigmatized as following the "bad precedent set by the zoologists." Willard Clute long ago remarked that he did not see "how doubling the specific name makes a plant any more specific"! However, since names are first of all an arbitrary device for precise reference to a given plant, the simple, direct, repetitive subspecific name is preferable to epithets which carry untenable implications.

The problems facing the Nomenclature Section of the botanical congresses of the future are still those which Weatherby cited a decade ago, namely, to implement the type concept, and to provide for the special needs of paleobotany and for the results of experimental taxonomy. To this should be added a continuing concern for *Nomina generica conservanda*. Pennell's plea for a sound basis for the election of a generic name to the conserved list has not been too well heeded. He said, "Few genera could be more inconsequential than *Glossostigma* of the Scrophulariaceae which is on the list, comprising some three species of tiny-flowered plants of tidal mud from India to Australia; why make it an exception to the rule of priority?" But Pennell would vainly seek *Calceolaria*, a handsome genus which numbers 400–500 species, twice preoccupied between 1753 and its adoption in 1771. He suggested the restriction of conserved names to large genera—those containing at least 50 species—as a working principle. For economic genera or others of special consideration there would be no size prerequisite. For example, *Eichhornia*, as the name for the water hyacinth, should rightly be conserved over *Piaropus*.

DeCandolle predicted the nature of taxonomic things to come "when all the plant forms in existence will have been described; when herbaria will contain indubitable material of them; when botanists will have made, unmade, often remade, raised or lowered, and redefined several hundred thousand groups from classes to mere varieties, and when synonyms will have become

more numerous than accepted groups." Short of this, here are the Rules.

JOSEPH EWAN

CONTRIBUTIONS TO THE FLORA OF VENEZUELA. *Fieldiana: Bot., Vol. 28, No. 4.*

By Julian A. Steyermark; 47 contributors. Chicago Natural History Museum, Chicago. $7.50 (paper). Pp. 679–1190. 1957.

Julian Steyermark explored several regions of Venezuela, notably the remarkable limestone cerros, between December, 1943, and June, 1945, under three sponsors: the U. S. Government (Cinchona Division, F.E.A.), the Chicago Natural History Museum, and the Venezuelan Government. He returned with the almost unprecedented total of 8550 items which now have been fully published upon. In this summary report, which is the fourth and last installment of his commentary, he gives totals for the expeditions: 9 genera heretofore undescribed, 642 new species, 68 new varieties, and 16 forms—an impressive inventory even for a tropical flora. It is interesting to note which plant families show the new genera: the Gramineae (1), Cyperaceae (2), Palmae (1), Eriocaulaceae (1), Euphorbiaceae (2), Melastomaceae (1), and Gesneriaceae (1). The new genera of Compositae discovered on Mt. Duida by Tate and his party have been found on these heretofore unexplored tepuias, as the block mountains are called. The Compositae yield the largest number of novelties in this report, with 51 species, followed by the Rubiaceae with 43 new species. Other families yielding 15 or more new species each include the grasses, sedges, pipeworts, bromeliads, orchids, pipers, euphorbs, guttifers, myrtles, malastomes, myrsinads, milkweeds, and bladderworts,—most of the novelties coming from the cerro summits or upper slopes. This annotated catalogue, running to nearly 1200 pages in all, is an impressive monument to the discriminating collecting, tireless industry, and careful workmanship of Steyermark. The accounts of families and genera contributed by 46 specialists obviously add to the value of the taxonomic decisions, which have in several instances been countered by Steyermark's own remarks. In a sense, then, this is a botanical forum of our present knowledge of the Venezuelan cerros and adjacent Andes. But this tally will not stand for long, since Bassett Maguire, who has explored the Tafelburg of Surinam, is now exploring other Venezuelan cerros. In 1791 Father Gumilla published a crude physiographic map of this country, locating the native tribes and the Jesuit missions. Printed across these very cerros are the words "Naciones no conocidas." Steyermark has added to the pioneer discoveries of the Schomburgks, Im Thurn, and others, and to the more recent ones of Tate and Cardona, to change Father Gumilla's verdict and raise a cerro of botanical knowledge in the jungles of Venezuela.

JOSEPH EWAN

FLORA OF PERU. *Field Museum of Natural History, Bot. Ser., Vol. XIII, Part IIIA, No. 2.*

By J. Francis Macbride. Field Museum of Natural History, Chicago. $5.50 (paper). Pp. 291–744 + ii pp. 1956.

Plants of Peru were extensively described and illustrated by Feuillée in 1714 and again in less detail by Frezier in 1717. If the Chicago Natural History Museum can see the completion of the *Flora of Peru* by 1964, it will be 250 years after Feuillée and will be the first of the several New World tropical floras now in progress to be completed. Macbride now resides in California but is assisted in his task by the selection of critical collections from the Museum's rich neotropical herbarium, and by the cooperation of local institutions in California.

When Jepson castigated botanists for speaking of the "compilation of a flora," he was justified because he deplored the publication of undigested treatments from heterogeneous sources which are presented in wholesale quotation. Macbride's *Flora of Peru*, launched in 1936, an avowed compilation, is better than most, and each part shows improvements. Although it lacks the finish of such floristic works as Fawcett and Rendle's *Flora of Jamaica*, which Macbride much admires, it has certain commendable features. A few of these may be mentioned: the entry in keys of two or more species side by side, when evidence for distinguishing the species is inconclusive but not so negative as to dismiss their acceptance altogether; the prominent citing, at the head of the treatment of families or genera of monographs or revisions used in the preparation of the various accounts; and the citing of the Field Museum photographs of types throughout (fortunately Macbride had completed the photographing of the Berlin types before the loss of the actual specimens in World War II). There may be a question as to the best position of commentary on types and application of names, whether it is more palatably incorporated into the running account or better set in smaller type and set off from the remarks of wider interest. Macbride's keys are frankly devised, not for indications of relationships, but for identification, and therefore often rest upon arbitrary characters. Macbride has a patent respect for nomenclatural priority and for maintaining the original orthography of names. There are incidental notes such as those on the feeding of the butterfly *Vanessa carye* [sic] on the mallow *Malvastrum scabrum*, an instance in which the insect is the same species from British Co-

lumbia southward, but the food plant is a different mallow in each region. The edaphic restriction of the mallow *Nototriche pellicea* to copper-rich soils underscores how much we still have to discover of life histories all over the world. Here one wishes there might be more such ecologic memoranda put on record.

JOSEPH EWAN

GLOSSARY OF INDIAN MEDICINAL PLANTS.

By R. N. Chopra, S. L. Nayar, and I. C. Chopra. Council of Scientific and Industrial Research, New Delhi. Rs. 8s. xx + 330 pp. 1956.

This is actually a concise dictionary of Indian medicinal plants. The result of a 30-year survey in that country, it lists all native Indian plants known to be used medicinally in India or elsewhere. Wherever possible, identifications of known drug plants are based on voucher herbarium material deposited in the herbarium at Jammu. An examination of the text will show that the authors have not limited their work to indigenous native plants of the subcontinent, for non-Indian species in such genera as *Annona, Bixa, Carica, Eucalyptus, Gossypium, Hippomane,* and *Opuntia* are also included.

The glossary consists of an alphabetical listing by genus and species together with important scientific synonyms (when necessary), and with the commoner vernacular names, a statement of medicinal use, and the distribution of the species in India. In addition, there are included brief descriptions of the active principles of plants, whenever known; and abbreviated references to the more important literature of medicinal plants, up to 1953.

In these days of increasing interest in the chemistry and pharmacology of the natural products obtained from plants, this glossary should be a welcome addition to the student working systematically on medicinal plants. It is another of the fine contributions to basic scientific literature financed by India's Council of Scientific and Industrial Research. One wonders how long it will be before the United States recognizes the value of such a basic work by subsidizing a companion piece for North American plants.

W. H. HODGE

FLORA OF SOUTHEASTERN WASHINGTON AND OF ADJACENT IDAHO. *Revised Edition.*

By Harold St. John. Students Book Corporation, Pullman. $4.25. xxv + 561 pp. + 1 pl.; text ill. 1956.

This revised offset edition of a highly useful *Flora* follows a growing but unfortunate practice of reprinting the old text unchanged and adding the new as a supplement at the end of the book. There is no wisdom in this. If there are some 800 changes to be made in the text of an identification manual, as in this instance, the book deserves to be completely reset. To do less is a misrepresentation of botanical progress. At the least the changes should have been incorporated into a reconstructed index.

The 28-page addenda will have to be searched for new nomenclatural combinations; these might have been listed separately at the end of the additions. Incidentally, the Addenda is dated March 29, 1956, but the verso of title reads "revised edition March 1, 1956." The whole is run in extremely fine offset print which is tedious to read. There are some interesting new records, as for example the Brazilian weed *Solanum sarrachoides,* and the Eurasian crucifer *Arabidopsis thaliana.* In the third edition, which we await with genuine interest, we hope there will be an account of distribution patterns that emerge from a study of this flora. The occurrence of the Sierra Nevadan *Dicentra uniflora* on Cedar Mt., Idaho, for example, may fill out a mosaic of Hudsonian Zone species. This third edition-to-be will surely, we hope, be completely reset with the genera and species arranged, not alphabetically as in the first two editions, but by affinities. Let a dubious convenience give way to significant taxonomic order. For the present we have a modestly priced, conveniently sized manual that will serve us in the interim.

JOSEPH EWAN

THE HISTORY OF THE BRITISH FLORA. *A Factual Basis for Phytogeography.*

By H. Godwin. Cambridge University Press, London; [Cambridge University Press, New York]. $16.50. viii + 384 pp. + 1 folded chart + 26 pl.; text ill. 1956.

As E. V. Wulff pointed out, Alphonse de Candolle (*Geographie botanique raisonnee,* 1885) first synthesized the approach that has come to be known as historical plant geography, and first recognized the interrelations of botanical geography, paleontology, and geology, in the fundamental problem of the "succession of organisms on the globe." During our century paleontological and geological facts about the Quaternary period have been accumulated at a steadily increasing rate, so that for a few areas considerable accurate knowledge is available about the vegetation of the past 10 to 25 thousands of years. The British Isles and areas around the North Sea and the Baltic are probably best known. In addition, the flora of the British Isles has long had the attention of plant geographers because of its steep gradients in affinities with continental floras and its striking segregations of species by habitats. Now Godwin has produced a detailed, very readable summary of the Pleistocene floras (including the interval some might call the post-Pleistocene) of Britain, bringing together all the paleobotanical evidence, but with special atten-

tion to facts derived by palynologists from fossil pollen and spores. This volume is truly what the subtitle calls "a factual basis for phytogeography," and its pattern deserves to be adopted widely.

The appearance of this volume marks a long-awaited achievement in plant geography—a comprehensive treatment of the more recent fossil floras of the British Isles in the light of the extensive and detailed investigations by the group led by Godwin and his Sub-Department of Quaternary Research at Cambridge. This work is a critical summary of fundamental significance, like *Stratigraphical and Paleontological Studies of Interglacial Fresh-water Deposits of Jutland and Northwest Germany*, by Jessen and Milthers (1928), and *Spat- und nacheiszeitliche Waldgeschichte Mitteleuropas nordlich der Alpen*, by Firbas (1949, 1952). To English-speaking botanists, moreover, Godwin's book is one in which the problems in plant geography seem familiar, because they have been so often cited to illustrate and to characterize effects of changing conditions of the Pleistocene upon temperate floras.

The Sub-Department of Quaternary Research at the Botany School, Cambridge, has become widely known for precise botanical techniques, close attention to stratigraphic details, and appreciation for the problems of paleoecological interpretation. The results of more than 25 years of research by Godwin and his colleagues are brought together in this volume and integrated with the extensive Tertiary and Quaternary macro-fossil records assembled and interpreted with great care by Clement Reid, Mrs. Mary Reid, Miss M. E. J. Chandler, and others. The paleobotanical considerations derive valuable support from the detailed distribution records now available for British species and from the comparatively rich knowledge of the natural histories of individual species in the flora.

Chapter II, on collecting and identifying plant remains, provides much useful information on the differential preservation of plant parts and the overlapping of characters between species. Advantages of cooperation with archeologists are demonstrated. Emphasis is placed upon the need for founding arguments upon the *presence* of particular species at specific times and places, rather than upon the *absence* of certain species.

Chapter III, The Background Scale of Quaternary Change, is an excellent introduction to the geography of the Pleistocene in the British Isles, and does indeed provide a background for consideration of Quaternary vegetation. Some knowledge of British geography, Quaternary chronology, and sedimentation processes will greatly increase the reader's appreciation of this chapter. A brief but useful set of annotations concerning the sites studied and published some years ago, and modern ideas of their relative ages, is presented in Chapter IV.

The main part of the volume is contained in Chapter V, The Plant Record, an exhaustive and critical catalog of available records of Quaternary vascular plants, including notations of the identifiable parts found as fossils. By means of this catalog one can obtain historical perspective for a wide variety of vascular plants. Pre-Roman records of certain weeds (e.g., *Barbarea vulgaris*, *Silene cucubalus*, *Ranunculus reptans*) and economic plants (e.g., flax, *Linum usitatissimum*, crab apple, *Malus sylvestris*, and various cereal grasses) provide new means for evaluating the inherent qualities of such plants. These records also permit critical appraisals of the climatic indicator values that have been assigned to fossil records of certain species, especially of forest tress; the author examines many of these in detail. The entire catalog is carefully collated with respect to systematic entities, common names of plants, sites that have yielded fossils, stratigraphic relationships, and pertinent literature. The paleobotanical records and paleoecological interpretations are presented for more than 500 species, representing about one-third of the total living vascular flora.

In Chapter VI, Pattern of Change in the British Flora, Godwin draws together the more significant facts from the fossil record and evaluates them in the light of modern distributions and the changing geography of the Pleistocene. The result is a well-organized exposition of the historical origins of modern distribution patterns. Somewhat less attention is given to histories of plant communities, although there is a tacit assumption that they possessed compositions similar to those of today, embodying similar groups of species. The fossil species used as indicators for different stages of climatic development in the Late-glacial and Postglacial are tested for their validity by comparison with evidence from other lines. Finally, the phytogeographic problems of Ireland are examined separately. It is demonstrated that the problems differ from those in Britain in degree rather than in kind, the western situation of Ireland and its isolation from Britain by the sea in postglacial time having made some of the floristic patterns more marked.

The brief concluding chapter treats the significance of the increasing numbers of species recorded from Late-glacial and subsequent time. Additions to the glacial flora of arctic and alpine plants arrived via land connection with the continent, but subsequent establishment of forests and inundation of the English channel slowed migration of species from that source. In the Neolithic and again in the Iron Age, species following man and his clearings caused fresh increases in the rate of invasion of new species and a reexpansion of many Late-glacial species that had been restricted by forest cover.

In this volume Godwin has provided not only an invaluable catalog of documented histories of British vascular plants but also a demonstration of the methods whereby Quaternary researches can be made to provide a "factual basis for phytogeography."

WILLIAM S. BENNINGHOFF

A FLORA OF THE MARSHES OF CALIFORNIA.
By Herbert L. Mason. University of California Press, Berkeley and Los Angeles. $10.00. viii + 878 pp.; ill. 1957.

Reasonably good manuals of the flora of limited areas or ecological conditions are not infrequent, and illustrated handbooks for the layman are published rather often. A superb flora illustrated by hundreds of high-class pictures of many of the plants concerned, and written in such a way that it is of equal importance for the amateur botanist and the professional is, however, seldom published, and especially in North America such books are very rare. It is, therefore, a double pleasure to be able to welcome one such manual, although it describes only plants of wet regions in a state as far away and distinct as California. The new *Flora of the Marshes of California* by Mason, professor of botany and director of the herbarium of the University of California in Berkeley, is just such a contribution as all botanists would have liked to write but only a selected few are able to produce. It is a book of unusual quality and rare splendor.

As stated in the preface to the book, it does not confine itself to the aquatic plants, but to all the species occurring typically on wet lands or in water in California. This makes the handbook considerably larger and more useful, and when reading it one repeatedly wishes that the author had gone still farther away from the wet areas and included everything growing wild in his Golden State. The introduction is concise and gives good information about habitats, the location and extent of the marshlands, and different other facts of floristic interest.

The manual itself is arranged like the usual modern floras, with general keys to the families in the front, descriptions of families and genera in appropriate places in the text, and keys to genera and species whenever needed. Latin names of species are followed by references to the author, place, and year of publication, and synonyms if any; and the descriptions are clear and detailed and are followed by information regarding habitat and distribution. Drawings illustrate critical species and also give details of interest for the exact determination of the taxa. The arrangement of families follows the Engler system, whereas genera are placed in an alphabetical order inside the families, but species are again in the taxonomical sequence.

The nomenclature applied is highly modern though reasonably conservative. Varieties seem to include both major and minor geographical races, as is usual in most American floras, and the subspecific category is very rarely applied. Decapitalization of specific epithets derived from personal names is not accepted. References are often given to recent papers on the taxonomy of the genera and species, thus facilitating a search for further information if required by the reader.

The author makes no secret of the fact that the taxonomy of several of the Californian species still remains somewhat confused, and in many cases he discusses the reason for the identifications followed in the book. Naturally, he does not always arrive at a definite conclusion, and one must wonder sometimes if an identification of the Californian plant with one originally described from Scandinavia may not be disputable. However, the book is not intended to solve all such problems but is mainly a manual for those interested in the plants of the marshes, and a certain degree of conservative treatment is, therefore, highly commendable.

In order to demonstrate some of the few points in which it is easy to disagree with the author in his judgments and selections of names, examples should be given. The grass species *Agrostis alba* is said to have as a synonym *A. stolonifera*. In Europe this is the other way round: *A. alba* is regarded as a confused name, and in eastern North America this name is frequently used for *A. gigantea*. The correct name should be *A. stolonifera*, with the synonym *A. alba* p.p., but it is perhaps not unlikely that even in California *A. gigantea* may be hidden under the collective and confused Linnaean name. The name *Phleum alpinum* includes, of course, the Californian plant only if taken in its original and unrestricted sense, but in the correct sense this species is met with only in the mountains of Central Europe, whereas the circumpolar (and Californian) plant is *P. commutatum*. It is rather misleading to list *Carex Lyngbyei* without mentioning the subspecific name of the Pacific plant, which usually is fairly well distinguished from the North-Atlantic species, as can be seen by comparing the picture here with those in the Icelandic and Faeroeic floras; the species was originally described just from these Atlantic regions and not from the Pacific. Even the listing of the "synonym" *C. cryptocarpa* would have improved the exactness in this case.

It is a common mistake to regard the American *Acorus* as identical with the sterile Eurasiatic triploid *A. Calamus*; the Californian plant is the fertile and widespread diploid *A. americanus* Raf., a very distinct species. The *Juncus bufonius* complex of California is tentatively identified with Scandinavian and eastern North American populations; it would probably be worthwhile to compare the Californian plants instead with some of the species segregated from the Asiatic populations in the Flora SSSR, which, in other cases also, may be a better guide to Californian plants than is commonly realized. It is apparent from the description of *Rumex Acetosella* that *R. angiocarpus* is included and probably also *R. tenuifolius*. These species, and especially the former, are considerably more frequent in California than the Linnaean species, at least according to herbaria in Europe and the eastern parts of North America.

Among the species which it is hardly correct to include under the names applied, but the correct name of which still remains unknown, is *Epilobium angusti-*

folium. The American populations west of Greenland certainly belong to another species, which in several characters stands closer to *E. latifolium*. For the time being, however, the collective name is to be used, although a reference to one of the varieties described from North America would be of interest. It is understandable that the author has preferred to take the species *Taraxacum officinale* in the widest sense, although a somewhat more detailed and less collective treatment would have been an improvement. It is rather likely that more than one good species and many agamospecies of this group are met with in the Californian marshes or their neighborhood, since this is the case elsewhere on the continent.

From these selected remarks it is evident that the taxonomy of the marsh plants of California may still be worth looking at, despite the qualified investigations this good book is based upon. Closer comparison with Asiatic material may be expected to induce some alterations, and if cytotaxonomical studies were added—and their results not ignored in the much-too-frequent Californian style—it is very likely that several differences of a very conclusive kind would emerge. The present flora makes the marsh plants of California ripe for such investigations, which in a few years could be completed as to their first and most conclusive steps.

Mason is known as a botanist of many abilities. His skill in several fields is well manifested in many scientific papers, and his knowledge of the literature and sharpness in observation are well documented. After this publication, it is evident that he is also a very able writer in the difficult field of scientific and popular manuals. The *Flora* is useful far outside the boundaries of the Californian marshes, and it is to be hoped that it is only the very first in a long series of such superb floras of other ecological conditions and regions much wider than his own Golden State.

ASKELL LÖVE

THE GENUS *FITCHIA* (COMPOSITAE). *Univ. Calif. Publ. Bot., Vol. 29, No. 1.*

By Sherwin Carlquist. University of California Press, Berkeley and Los Angeles. $2.50 (paper). 144 pp.; ill. 1957.

"Where would you put *Fitchia*?" was Setchell's question to many doctoral candidates, for Polynesian problems in plant geography interested him intensely, and few puzzles excited him so much as the origin and sibship, as he would call it, of *Fitchia*, a tree composite of a prevailingly herbaceous plant family. The 6 species of this handsome genus are all narrow endemics: 2 to Tahiti, and 1 each to the oceanic islands of Raratea, Mangareva, Rapa, and Rarotonga. They are shrubs to trees, *Fitchia speciosa* reaching a height of 30 feet or more, a diameter of 6 to 8 inches, and anchoring itself into the island slopes by prop roots. Some daisy!

Carlquist's study, a model of its kind, attempts to muster all the lines of evidence to determine the taxonomic position of *Fitchia*. He finally proposes a new subtribe, Fitchiinae, of the tribe Heliantheae, to accomodate it. Twenty characters of corolla, achene, pappus, secretory canals, style branches, and leaves are compared for 10 helianthoid genera, including *Helianthus* and *Bidens*. All 10 have vasculated pappus structures and leaves provided with secretory canals. All 6 species are certainly relicts, as is the genus itself, the diploid genome of 70 to 80 suggesting polyploidy. *Fitchia speciosa*, the most isolated of the sextet, differs most from its congeners morphologically. Vasicentric wood parenchyma is uniformly present in the genus; moreover, the pith of *Fitchia* most closely agrees with that of the helianthoid genera of the closest floral morphology and anatomy. Likenesses obtain with the semiarborescent genus *Oparanthus* and with the tree genus, *Petrobium*. Three species of *Oparanthus* occur on Rapa, where one *Fitchia* also occurs, but, as if to baffle the plant geographer, *Petrobium*, a monotypic discoid-flowered tree, is another famous prisoner of the island of St. Helena. Both genera differ from *Fitchia* by their relatively small tetramerous disc flowers and the sexual differentiation of flowers.

Carlquist's monograph is illustrated by 96 high quality photomicrographs, as well as many excellent line drawings by the author, and rests on a bibliography of 65 references. Carlquist concludes that fixing relative primitiveness in the Sunflower Family is not easy, and although *Fitchia*, with floral secretory canals, median corolla veins, and vasculated awns, looks like a prototype, he feels that before a decision is reached the Mutisieae must be more thoroughly examined.

JOSEPH EWAN

SYSTEMATIC ANATOMICAL STUDIES ON *MYRRHIDENDRON* AND OTHER WOODY UMBELLALES. *Univ. Calif. Publ. Bot., Vol. 29, No. 2.*

By Rafael Lucas Rodrigues. University of California Press, Berkeley and Los Angeles. $3.50 (paper). Pp. 145–318; ill. 1957.

Jens Clausen published a three-dimensional reticulate diagram of the phyletic relationships between two genera of Compositae in his *Stages in the Evolution of Plant Species* (1951), based on a long series of morphological, cytogenetic, and field studies of the plants in question. A hundred years from now the concepts of plant phylogeny will have been expressed in hundreds of such diagrams drawn from a synthesis of data from these fields as well as from plant anatomy, serodiagnosis, and surely other yet-to-be-tested evidence. Meanwhile hundreds of studies along the lines of Rodriguez's appraisal of the degree of affinity between the umbels and the araliads and basic to these the Cornaceae, Nyssaceae, and Garryaceae, must be reported upon. His in-

vestigation has been conceived with thoroughness and imagination, and an awareness of previous studies. Three objectives were before him, namely, to describe the anatomy of the woody Costa Rican umbellifer *Myrrhidendron donnell-smithii*, to compare secondary xylem histologically throughout the parsley family and as widely as possible in the aralia family as well, and, finally, to derive some phylogenetic conclusions as to the relative advance or primitiveness of the families comprising the Umbellales. All three objectives have been meritoriously won in Rodriguez' study. Special importance rests on the position of the woody types in the predominantly herbaceous Umbelliferae. Three subfamilies, Hydrocotyloideae, Saniculoideae, and Apioideae, contain woody genera, but these subfamilies form a phylad, and woodiness as an index of primitiveness is precluded. The genus *Myrrhidendron* (Apioideae) consists of 4 species. 2 of them suffrutescent Colombian species and 2 truly woody species, *M. mazonii* of Panama and *M. donnell-smithii* of Costa Rica's volcanoes. The latter species reaches a diameter of 40 cm. and a height of five meters or more, and sometimes grows epiphytic on *Buddleia* or *Escallonia*.

Rodriguez devotes several paragraphs to a historical recapitulation of the place of the Umbellales in schemes of classification from Theophrastus and the herbalists, who made no attempt to express phylogeny, to modern positions. All evidence suggests that the umbellifers and the araliads "are so close that no single sharp difference exists that will separate all members of one group from those of the sister family." Three araliads, *Horsfieldia*, *Delarbrea*, and *Myodocarpus*, have mericarp-like fruits, and to offset this anomaly 9 genera of umbellifers have woody stems.

Ecologists interested in the tropics will welcome the "observations in the field" made on the slopes of the Costa Rican volcanoes, illustrated with 12 field photographs of living plants. Nearly 300 references are cited, witness of a vast amount of background reading, and there are 65 line drawings and 32 photomicrographs of anatomical details each of which may be traced to its voucher specimen in the herbarium of the University of California.

JOSEPH EWAN

FLORA OF GUATEMALA. *Part II: Grasses of Guatemala. Bamboos. Fieldiana: Bot., Vol. 24, Part II.*

By Jason R. Swallen and F. A. McClure. Chicago Natural History Museum, Chicago. $6.00 (paper). x + 390 pp.; ill. 1955.

Guatemala, with an area almost exactly the equivalent of Pennsylvania, has 455 species of native and introduced grasses, belonging to 120 genera. E. M. Gress described "about 250 species and varieties" for Pennsylvania in 1924. Accordingly, this rich Guatemalan grass flora attracts attention. It is partly due to the physiographic diversity of the country which reaches from the tierra caliente of the banana coasts to the subalpine meadows of the tierra fria. Three typical boreal grasses of Guatemala are *Trisetum*, *Calamagrostis*, and *Poa*. *Poa tacanae* ascends to 13,800 ft. on Volcán Tacaná. Quite expectedly, the floristic tie-in is with Mexico to the north, but it is also with Costa Rica and the Andes. The three largest genera, *Panicum*, *Paspalum*, and *Andropogon*, account for one-third of the total grass flora.

This is the first account of the Guatemala grasses as a separate study. In conformity with the plan for the *Flora of Guatemala*, of which this comprises Part II, the genera and species are catalogued alphabetically. This is to be deplored. It serves very well for a stamp album but is ill-suited to an identification manual, as surely this *Flora* purports to be. If an unknown grass resembles *Festuca* but fails to be accounted for under that genus, there is no recourse but to return to the generic key, which has necessarily been constructed on a selection of characters that may not emphasize what might quickly be learned were *Brachypodium* placed next to *Festuca*. Nor are generic alliances indicated in the separate accounts, although the size and distribution of each genus is briefly stated. One will not easily discover to what tribe the genus *Eriochrysis* belongs although it has been incorporated with *Saccharum*.

Economic uses and bits of folklore are mentioned, and native vernacular names are generally supplied, but familiar Nordic names for *Avena*, *Lolium*, and *Cenchrus*, for example, aren't even whispered. Nearly all the genera are illustrated by line drawings—113 in all, many original; but their value for the user would have been enhanced by the late Prof. Fassett's device of directing attention to diagnostic features by means of arrows, in the manner of the Peterson Bird guides. F. A. McClure, who contributed the text for the Bambuseae, has provided very full descriptions and notes on types, and these should prove widely useful for others concerned with technical names of bamboos.

JOSEPH EWAN

SAXIFRAGA OF THE HIMALAYA. *1. Section Kabschia. Bull. Brit. Mus. (nat. Hist.), Vol. 2, No. 4.*

By Harry Smith. British Museum (Natural History) London. 15s. (paper). ii + pp. 85-129; ill. 1958.

ECONOMIC BOTANY

USING WAYSIDE PLANTS. *One Hundred Useful Plants of Northeastern United States and How to Use them. Second Edition.*

By Nelson Coon. Eaton Press, Watertown. $3.00 254 pp.; ill. 1958.

This revised edition of a little volume issued first in 1957 has been described as a kind of present-day homespun herbal. The volume does have the flavor of an herbal. It treats "100 useful plants of the northeastern United States" and explains how they may be used, whether for food, handicrafts, or simple remedies. The author writes at the level of the average nature lover, including boys and girls of scouting age. For this audience the volume is a gold mine of practical though generalized information.

Although there is a wealth of interesting items, the presence of certain statements would suggest that the reader proceed with caution, especially with regard to edible wild plants, where a more authoritative work on this subject, such as that of Fernald and Kinsey (1943), would be much preferred. For example, the statement (p. 183) that horsetails "might be considered an emergency food" is unfortunate in view of the fact that there are many records of these plants causing serious poisoning of stock. Few would agree that poison sumac "is not as virulent as poison ivy"; on the contrary, it is equally virulent and by some considered more poisonous than its commoner relative.

Since the author has used botanical names as the key in making his lists of plants, it would seem appropriate to utilize the proper names in current use, yet this is not always done. Considering the availability of such up-to-date works as Gray's *Manual of Botany* (8th edition) there is little excuse for not being accurate, especially when scarcely a hundred scientific names are used. For example, the binomial for the Canoe Birch should be *Betula papyrifera*, not *Betula alba*, the name for the European White Birch; Ground Juniper is *Juniperus communis* var. *depressa*, not *Juniperus communis*, which is Common Juniper, an arborescent tree; the more familiar species of Cranberry is *Vaccinium macrocarpon*, not *Vaccinium oxycoccos;* the Ground Nut is *Apios americana*, not *Apios tuberosa*, a synonym; our native Goldthread is *Coptis groenlandica*, not *Coptis trifolia*, a species of Eastern Asia and Alaska.

Despite such irritating and unnecessary errors, this publication will doubtless bring to a new generation interesting information that was common knowledge in rural America a half-century ago.

W. H. Hodge

An Encyclopaedia of Annual and Biennial Garden Plants.

By C. O. Booth. Faber & Faber, London; [The Macmillan Company, New York]. $12.50. 488 pp.; ill. 1957.

This addition to the steadily growing list of garden encyclopedias is devoted to ornamental annuals and biennials and their cultivation in the British Isles, with reference, however, to many species available for cultivation in Europe and North America.

Part I is a comprehensive discussion of this branch of floriculture in all its aspects. Among the subjects treated are: the characteristics of annual and biennial plants; raising them from seed; their cultivation in the open and under glass; insects and other pests; and parasitic and nutritional diseases and their control. Plans for borders are furnished, together with a long list of species grown for their flowers, with the average height, time of flowering, hardiness and duration, and color indicated in each case. There are shorter lists of foliage plants, climbers, scented flowers, and species suitable for rock gardens, for shady places, or for cutting or winter bouquets.

Part II presents data on some 1400 individual species, derived in the majority of instances from the personal experience of the author. The nomenclature is based on *Hortus Second*. The genera are arranged alphabetically. In each case the common name, family, hardiness and duration, native countries, synonyms, and the most useful generic characters are given.

The information regarding species is more detailed and includes notes on the proper location, type of soil, time of flowering, value for cutting, seed planting, thinning, watering, pests, and diseases. Wherever a species is valuable commercially, separate instructions are given for its commercial cultivation. Brief accounts of American methods are included where these differ from the practice in Great Britain.

There is a glossary of the botanical terms used in the book, together with lists of specific names and their meaning; common names and their Latin equivalents; chromosome numbers, seedsmen and botanic gardens in other parts of the world able to supply seeds of the unfamiliar species; and firms manufacturing insecticides and fungicides. An index to pests and diseases and a general index to Part I are also appended.

Although not as many genera are considered as in some of the American encyclopedias, more information is given for the individual species. The book should be a valuable reference work both for the amateur and the commercial grower.

Albert F. Hill

Successful Gardening Without Soil.

By C. E. Ticquet; foreword by R. H. Stoughton. Chemical Publishing Company, New York. $2.75. 175 pp. + 8 pl.; text ill. 1956.

This is a very practical book dealing with all phases of soilless culture. The author, drawing on his own experience as well as that of others, gives a clear account of the principles and practices of the various methods of growing plants in water, sand, or gravel. He does not overemphasize the simplicity of soilless culture, but

rather points out the many pitfalls and difficulties and how they may be overcome.

The various chapters are entitled: The Beginnings; Water; Theory of Solutions; The Solution in Practice; Making and Mixing; Management of Solutions; Water Culture; Sand Culture; Gravel Culture; Commercial Soilless Culture; Soilless Culture for Education; Where Have I Gone Wrong?; and The Future.

An appendix includes metric tables, conversion factors, atomic and molecular weights, and formulae. There is a short bibliography and index. Written in a clear simple manner, this book should be invaluable to the beginner. The professional grower, also, will find much of interest and guidance.

ALBERT F. HILL

PLANT DOCTORING IS FUN.

By Cynthia Westcott. D. Van Nostrand Company, New York. $4.50. viii + 280 pp.; ill. 1957.

Whether or not the reader is familiar with Cynthia Westcott as a lecturer, or with her entertaining and informative books and articles on gardening, he will be delighted with this amusing autobiography, *Plant Doctoring is Fun*. This is not only a fascinating account of the author's very unique and energetic life, but it gives a good picture of the training and the everyday work of a plant pathologist with all its opportunities for service, and its hazards and pitfalls as well.

The author tells of her student days at Wellesley, of her graduate work at Cornell, and subsequent activities as a research assistant, including a memorable trip to Europe. Then in 1934, following a few years at the New Jersey Agricultural Experiment Station, she set up in business with an entomological friend, Irene Dobroscky, as partner, under the registered name, "The Plant Doctor." The remainder of the book is a frank and intimate story of her subsequent career, culminating in a citation presented by the American Horticultural Council for outstanding accomplishment in the science and practice of plant pathology.

Visiting and treating gardens, consultations, lecturing, arranging exhibits, attending conventions, traveling to famous homes and gardens all over the country, working and experimenting in her own garden, particularly with her roses, investigating and finally conquering the azalea blight as a wartime appointee of the U. S. Department of Agriculture, writing innumerable magazine and newspaper articles and books, and cooking (even recipes are included)—all are described in her own inimitable manner.

ALBERT F. HILL

CORN AND ITS EARLY FATHERS.

By Henry A. Wallace and William L. Brown. Michigan State University Press, East Lansing. $3.75. xi + 134 pp. + 27 pl. 1956.

This interesting little book by two of the world's leading corn experts tells the important and dramatic story of the development of our modern corn. In scientific but perfectly intelligible language, it describes the two complete changes that have taken place in corn in the relatively short space of 156 years.

The corn which the Indians grew was gradually improved until by 1850 it was very different, and by 1920 it had been still more altered. Then came the spectacular development of hybrid corn, so far-reaching that today 99.9% of the corn grown in the Middle West is of hybrid origin.

The authors are particularly interested in the men who made all this possible: the first scientific observers of sex in corn; the men who were responsible for developing the 14- to 24-rowed corn which replaced the Indian 8-rowed maize; and the modern scientists who by their experiments were able to create hybrid corn. Cotton Mather, Paul Dudley, and James Logan in the eighteenth century; John Lorain and Joseph Cooper, practical farmers, and Peter Browne, a Lafayette College professor, in the early nineteenth century, were among the first to observe or put to use the benefits of crossing different varieties of corn.

During the latter half of the nineteenth century science was brought to bear on the problem of corn improvement. Much significant work, such as the recognition of the principle of hybrid vigor, was carried on at the Michigan Agricultural College under the leadership of William James Beal. Meanwhile, practical corn breeders like Robert Reid, George Krug, and Isaac Hershey were developing many valuable inbred strains, such as the famous Reid Yellow Dent, while Perry G. Holden was instrumental in spreading these far and wide in the Corn Belt.

With the onset of the new science of genetics, the stage was set for a completely new and different approach to corn improvement—the development of hybrid corn. The work of George H. Shull, Edward M. East, Harvey M. Hayes and Donald F. Jones in this connection is summarized. A final chapter deals with the "forgotten corns" which may be the reservoir from which the corn for future generations may come. There is a short bibliography of pertinent references.

ALBERT F. HILL

CROP PRODUCTION IN THE SOUTH. *Southern Farm Series.*

By Glenn C. Klingman. John Wiley & Sons, New York. $4.95. viii + 416 pp.; ill. 1957.

This volume is designed to give agricultural students a knowledge of the basic sciences in so far as they apply to modern farming. It stresses in a simple conversational style the reasons why various practices are carried on, and presents concrete facts regarding what tasks are necessary and how and when they should be carried on. Five chapters are devoted to a general discussion: How Plants Grow and the Plant Kingdom; The Soil and Plant Growth; Crop Improvement through Plant Breeding; Good Seed, Germination and the Seedling; and Weed Control. Ten chapters deal with specific crops: Forages (Pasture, Silage, Hay); Cotton; Corn; Tobacco; Wheat, Oats, Barley and Rice; Peanuts; Soybeans and Cowpeas; Sorghums; Sweet Potatoes; and White Potatoes.

A series of review and study questions is appended to each chapter. The book is copiously illustrated with photographs, diagrams, charts, tables, and maps. There is also a list of conversion factors and an adequate index.

ALBERT F. HILL

UREDINEES DU MAROC, I. *Trav. Inst. Sci. Chérifien, Série Botanique: No. 11.*

By A. L. Guyot and G. Malençon. Société des Sciences Naturelles et Physiques du Maroc, Rabat. 1,300 fr. (paper). v + 184 pp. + 5 pl.; text ill. 1957.

This is the first of a projected series of several contributions dealing with the rust flora of Morocco, based on collections made by the authors in 1952–1956. Essentially taxonomic in approach, 93 species are considered, distributed by genera as follows: *Aecidium*, 3 spp.; *Coleosporium*, 2; *Gymnosporangium*, 2; *Kuhlneola*, 1; *Melampsora*, 6; *Phragmidium*, 4; *Puccinia*, 57; *Uredo*, 2; *Uromyces*, 15; and *Zaghouania*, 1. Six new species are proposed, including 1 of *Gymnosporangium*, 1 of *Puccinia*, 2 of *Uredo*, and 2 of *Uromyces*.

Because of its economic importance, *Puccinia graminis* has been studied extensively by the authors, the studies being based on approximately 100 collections parasitizing 15 genera and 26 species of Gramineae, and embracing new host records and information concerned with physiological races. The volume is well indexed, including both a host index and an index of rust names.

F. T. WOLF

PLANT PROTECTION CONFERENCE, *1956. Proceedings of the Second International Conference at Fernhurst Research Station, England.*

Academic Press, New York; Butterworths Scientific Publications, London. $9.00. xi + 315 pp. + 11 pl.; text ill. 1957.

This conference was held at Fernhurst, Sussex, June 18–21, 1956. Sponsored by Plant Protection, Ltd., a subsidiary of Imperial Chemical Industries, the conference was attended by some 200 delegates from 42 countries. The various papers presented are grouped into 6 topics: world aspects of crop protection; genetics in relation to crop protection; mechanisms of toxicity; the role of systemics in crop protection; residual effects and user-hazards of crop-protection chemicals; and applying crop-protection chemicals.

The list of contributions includes the following: World aspects of plant protection (J. G. Knoll); Genetics in relation to crop protection (W. F. Hanna); The physiology of immunity of some agricultural plants (K. T. Suchorukov); Black arm disease of cotton and its control (R. L. Knight); Mechanisms of toxicity with special reference to fungicides (S. E. A. McCallan); Some physico-chemical and physiological problems associated with the mechanism of toxicity of insecticides (J. W. L. Beament); The mechanism of toxicity of insecticides and fungicides (J. T. Martin); The role of systemic insecticides in world agriculture (R. L. Metcalf); Systemic fungicides and bactericides (P. W. Brian); Chemical weed control in Sweden (E. Åberg); Comparative tests with chemical products for preventing the sprouting of potatoes (V. J. Masten and J. Horevar); Hazards arising from the use of toxic chemicals in agriculture (J. M. Barnes); The problem of residues from pesticides in foodstuffs from the point of view of health (R. Fabre and R. Truhaut); The residual effects of crop-protection chemicals in the soil (F. J. D. Thomas); The mechanics of producing sprays of different characteristics (R. P. Fraser); Mistblowing and mistblowers (E. W. B. van den Muizenburg); and Methods of insecticide application against the desert locust (R. C. Rainey).

While, as one would anticipate, the contributions are somewhat uneven in quality, the volume contains a wealth of information concerning the menace to world food supplies by disease and insects, and the means currently used to combat these. Laboratory experimentation on the mechanism of toxicity of fungicides, insecticides, and herbicides goes hand-in-hand with field studies. The widespread applications of chemicals to food crops has created problems and hazards both to the user of the chemicals and the ultimate consumer of the food. While much has been accomplished, much remains to be done in connection with the development of better systemic insecticides and fungicides and the problems of toxic residues on foodstuffs and in the soil.

The discussion of the various papers presented furnishes, in many instances, reading equally as interesting as the papers themselves.

FREDERICK T. WOLF

GENERAL AND SYSTEMATIC ZOOLOGY

THE FAUNAL CONNECTIONS BETWEEN EUROPE AND NORTH AMERICA.

By Carl H. Lindroth; foreword by P. J. Darlington, Jr. John Wiley & Sons, New York. $15.00. 344 pp.; ill. 1957.

One of the most discussed problems in biogeography is the connection between Europe and North America. When scientists began to study the fauna and flora of both sides of the Atlantic, they soon became aware that there are rather close relationships between the animal and plant life in the Old and the New Worlds. In the past many speculations have been put forward in explanation of this phenomenon, yet still there is no unanimity of opinion as to the most likely explanation. It is evident, however, that no one explanation will suffice, and it is not unlikely that several of the hypotheses which now might seem somewhat controversial will contribute to the ultimate solution of this riddle.

Carl H. Lindroth, of the University of Lund in Sweden, is an entomologist with wider experience in northern lands than any other biologist, and his knowledge of other animals and plants within these regions is also considerable. His dissertation on the Icelandic insects, in 1931, is a classic in the biogeography of the North Atlantic, and although his hypothesis of glacial survival and land bridge connections with Iceland were met by many biologists with some scepticism when they were coined, they are now regarded as strongly substantiated by various evidence. The sharp observation and clear foresight upon which they were based make one feel that the present text might also become one of the classics of biogeographical studies for the North Atlantic in time to come.

The book is so concentrated that for the most part it will have to be used only as a reference work for those interested in the distribution of biota common to both continents. The explanatory chapters are, however, a fascinating lecture for those interested in these problems, although they are written in the much too common style which some scientists seem to feel is necessary to tell "nothing but the truth"; in fact, many of the best ideas have become almost lost between the facts. Even those interested might notice that somewhat too strong an emphasis has been put on the animals recently introduced by the aid of human agencies, since these are hardly of any major interest for the real problem, although their exclusion is necessary for its explanation. The author shows that of the 908 species he has selected from the group common to Europe and North America, between 41% and 46% must have been introduced by man, mainly in a westward direction, and very often in ballast or settlers' effects. The remains are regarded as being either circumpolar in various degrees or amphi-Atlantic. It is evident that this element should be the basic material for discussions of the connections indicated in the title of the book, but the author prefers to emphasize the importance of the introductions and treats the main subject rather superficially in what is only a small part of the text.

In the case of Iceland, which certainly holds the key position in these questions, the author showed in 1931 that some of its insects must have invaded the country from Europe by aid of a land bridge, and then survived the last glaciation in the country. This hypothesis is now altered in such a way that the land bridge is supposed to have disappeared at least prior to the penultimate glaciation, at the same time as it is supposed to have reached further west than Iceland, though not west of Greenland. The occurrence of some of the indigenous animals in America or western Europe is explained by aid of this putative land bridge, while most of the indigenous element is regarded as "remnants of a broken-up area of circumpolar type" (Hultén's hypothesis). There are strong reasons to feel that this explanation is very plausible, although botanical and paleobotanical evidences hardly support the opinion that the connection has not reached west of Greenland at some time. The entomological information behind the hypothesis is probably genuine, and the general zoological data are as trustworthy as any such can be; however, the attitude shown by the author toward some detailed and very exact determinations of botanical material supported by cytological data may seem to indicate that the exactness in his own species concept may not be beyond criticism, either. Such an exactness is a fundamental requirement for any correct explanation in biogeography.

Although the book concerns the faunal connections, it discusses very extensively the relationships between the plants of both continents. It would take too much space to criticize some of the botanical conclusions of the author or his judgments of the quality or importance of certain works outside his own field—especially I am thinking of some statements regarding the Vineland story and some of the botanical discussions. It is, to say the least, doubtful that the European introductions in the Newfoundland flora are "easily extracted" from Gray's *Manual*; there the author also makes some deplorable mistakes. At the same time as Lindroth feels competent to discard the most exact evidence available for the occurrence of American plants in Iceland, he requires "more realistic points of view" from the botanists! It also begs for a retort when he makes so trite a remark about one of his colleagues as that his "method is not one of science, but of faith." Some biologists and geographers might still feel so about certain of Lindroth's own hypotheses. Such remarks do not increase the scientific value of the treatment itself.

The book nevertheless remains a valuable contribution to our knowledge of the relationships between the faunas (and floras) on both sides of the North Atlantic.

All conclusions are perhaps not equally well founded, and some biologists may object to the presumption of certain statements. But although many more and detailed investigations, applying more exact methods of comparison, must be performed before the conclusions can approach anywhere near finality, this book will always be regarded as a milestone in the right direction. It is a stimulating and concentrated contribution to our knowledge of a biogeographical event of utmost evolutionary significance.

ASKELL LÖVE

LES LÉPIDOPTÈRES DE L'AFRIQUE NOIRE FRANÇAISE. *Vol. 14, Fascicle 1. Introduction: Structure, Moeurs, Récolte, Conservation, Classification.*

By A. Villiers. Institute Français d'Afrique Noire, Dakar. 380 fr. (paper). 84 pp.; ill. 1957.

LES LÉPIDOPTÈRES DE L'AFRIQUE NOIRE FRANÇAISE. *Vol. 14, Fascicle 2. Papilionidés.*

By A. Villiers. Institute Français d'Afrique Noire, Dakar. 330 fr. (paper). 48 pp.; ill. 1957.

LES LÉPIDOPTÈRES DE L'AFRIQUE NOIRE FRANÇAISE. *Vol. 14, Fascicle 3. Lycaenidés.*

By H. Stempffer. Institute Français d'Afrique Noire, Dakar. 1,400 fr. (paper). 228 pp.; ill. 1957.

Much remains to be learned about the fauna of Africa. There is an especially rich entomological field of investigation still to be exhausted. Accordingly, publications on the insects of Africa are to be welcomed. The first of the 3 fascicles noted here deals with the morphology, life history, behavior, general natural history, and collection and preservation of the various life stages of the Lepidoptera. This is a brief and useful introduction to those topics; while it says little that is not to be found in butterfly books, it does present it in a place accessible to those who are especially interested in the African Lepidoptera.

The second fascicle concerns itself with the systematics of the Papilionidae. One especially commendable feature is the inclusion of life history data and an illustration for each species for which the information is known.

The third fascicle treats of the Lycaenidae. Here life history data are almost entirely absent. It is regrettable that the half-tone illustrations are not in color, but, as the author remarks, the cost would have been prohibitive.

V. G. DETHIER

ZOOLOGY. *Second Edition.*

By Alfred M. Elliott. Appleton-Century-Crofts, New York. $7.00. x + 746 pp.; ill. 1957.

The second edition of this highly successful textbook (*Q.R.B.*, 28: 188. 1953) is much like the first. The headings have been recast, a few of the illustrations slightly modified, some new ones added, and some parts of the text have been expanded. The section on ecology has received most revision and is now one of the major subdivisions of the book, of which there are 8 instead of 7. The list of references has been enlarged from 44 to 61 titles, the pages have increased in number from 719 to 746, but essentially this is the same book.

HENRI C. SEIBERT

PRÉCIS DE BIOLOGIE ANIMALE. *Fifth Edition.*

By M. Aron and P. Grassé. Masson & Cie., Paris. 5,900 fr. viii + 1413 pp. + 2 pl.; text ill. 1957.

Earlier editions of this book have been previously noted in these pages (*Q.R.B.*, 25: 82, 1950). A comparison between the 3rd edition (1947) and the present one reveals some minor changes, but the book as a whole is essentially the same. The type has been recast, the quality of the paper improved, and the text expanded. Without reading the entire book, one can note the inclusion of new topics such as cytoplasmic inheritance and the mode of gene action, as well as the modernization of certain topics such as biochemical and physiological reactions. For a survey of zoology in its broader aspects, as much information is packed between these two covers as in any other volume I am aware of.

HENRI C. SEIBERT

REPTILES ROUND THE WORLD.

By Clifford H. Pope; illustrated by Helen Damrosch Tee-Van. Alfred A. Knopf, New York. $3.50. xv + 194 pp.; ill. 1957.

This is an informative and interesting book for youngsters. The first of its two major parts is concerned with reptile life and contains 17 chapters dealing with locomotion, eating, reproducing, size, growth, age, reptiles of ancient times, dangerous reptiles, reptiles as pets, etc. The second section, of considerably shorter length, is devoted to a continent-by-continent discussion of reptile distribution. The writing is good and the material selected never trite. About one-fifth of the pages are illustrated with effective drawings by Helen Damrosch Tee-Van.

Over the years Pope has produced a series of technical and popular works of such excellence that it is not a serious reflection to say that the present book does not measure up to his others. There are missed educational opportunities where the author simply introduces a topic and fails to add the few additional statements necessary to provide a youngster with an exciting insight into an unfamiliar biological phenomenon.

There are a number of anthropomorphisms and typographical errors.

But the book was not intended for my generation, so I passed it on to a ten-year-old I know. After he had had a chance to read it, he told me, without reservation or qualification, that it was a "mighty fine" book. I am quite ready to defer to his judgment.

ARNOLD B. GROBMAN

THE LIFE OF THE SHREW.

By Peter Crowcroft; introduction by Maurice Burton. Max Reinhardt, London. 15s. 166 pp.; ill. 1957. This interesting monograph is primarily an observational rather than an analytical account of the behavior and ecology of the shrews of the British Isles. It is a provocative little book and a useful one for those whose tastes run to natural history. Particularly, it should serve to stimulate beginning students with a previous interest in field biology. Crowcroft is obviously an enthusiastic admirer of these small mammals, and his patience and perseverance have been rewarded by his acquisition of an intimate knowledge of many facets of their activity and behavioral patterns. His very extensive observations have not, however, been recorded as objectively as one might wish. One feels that *The Life of the Shrew* is primarily directed toward readers who have been addressed as follows on the publisher's dust jacket: "Details of trapping for shrews are provided in an Appendix, which will be extremely valuable to amateur naturalists and to Biology teachers who wish to introduce live shrews into classroom study." A brief bibliography, an index, and an interesting introduction on shrew folklore and superstitions by Maurice Burton add to the usefulness of this contribution.

DAVID W. BISHOP

THE WARBLERS OF NORTH AMERICA.

Edited by Ludlow Griscom and Alexander Sprunt, Jr.; illustrated in color by John Henry Dick. The Devin-Adair Company, New York. $15.00. viii + 356 pp. + 35 pl. 1957.

The story of the origin of this book is an interesting one. It grew out of an original determination by the artist, John Henry Dick, to paint all species of warblers that breed north of the Mexican border. All these species were painted or sketched in the field, an undertaking that required numerous field trips to visit the natural haunts of the birds. A brief write-up was then thought fitting for each plate, and so such well-known ornithologists as Alexander Sprunt Jr. and Ludlow Griscom were consulted. Out of this grew the idea to include all warblers of the North American continent as far south as the Panama Canal, and the aid of other ornithologists was solicited. Finally, the coverage was made to include South America, and the text expanded until some two dozen men have contributed to this compendium.

Although there are 19 chapters, some are short (1 page) and the one that describes the warblers of the U. S. and Canada (200 pages) comprises more than half of the book. In this chapter, the text on each species has been written up by the man or men most familiar with it and includes comments on peculiar or noteworthy characteristics of the bird, its natural habitat, nesting behavior, song, etc. Field characters, nesting dates, voice, food habits, and general range are briefly described in smaller type. Each subspecies has its range delineated and is briefly differentiated. A rather crudely drawn outline map pictures the breeding range. Other chapters give information on warblers in general (Skutch), on their classification (Griscom), the technique of study (Griscom), songs (Griscom), interpretations of songs (Gunn and Borror), distribution (Griscom), foraging range (6 contributors), warblers of Mexico (Blake), of the West Indies (Bond), migrants and residents in Central America (Skutch), of Panama (Eisenmann), of South America (Blake), of Alaska (Lincoln), of British Columbia (Munro), of the Prairie Provinces (Godfrey), and of Eastern Canada (Clement and Gunn). Appendices provide a check-list of the warbler family, a suggested reclassification of the warbler genera, and comments on the Gulf migration routes of 38 eastern warblers.

This thumbnail outline of the book's contents suggests an ambitious and enthusiastic undertaking. From a scientific viewpoint we note that most of the material presented here has already appeared in the literature, especially in the treatises of Chapman and Bent. What is novel, however, is the inclusion of all the warblers of both continents. Unfortunately, the discussions on the neotropical forms are distressingly brief, in large part a reflection of our lack of knowledge concerning their ecology. Since the song of warblers is of great importance to the field man and at the same time poses considerable difficulty, much emphasis has been placed on the subject, and should make this an invaluable contribution.

The color illustrations deserve special comment, since they were the primary motivation for this book. There are 35 color plates and numerous pen-and-ink sketches. Some plates contain just one species posed in a natural setting; others, as many as 14 species crowded together. It is obvious that the Central and South American species did not receive as generous a treatment as the North American ones. Not only are the former more crowded, but sex and age differences are not indicated—as though time and money were running out. For the most part the renditions are satisfactory, the poses and backgrounds pleasant, scientific accuracy maintained, and the color faithfully reproduced, except for 2 or 3 plates (Pl. 2, 13) where the greens and blues

appear unnatural. Some plates (e.g. 1, 5, 19) stand out for one reason or another, and the pictures of the foreign birds are stimulating for the reason that very few of them have ever been illustrated before.

No bird student, regardless of degree of experience, should fail to add this exciting contribution to his library.

HENRI C. SEIBERT

CHECK-LIST OF NORTH AMERICAN BIRDS. *Fifth Edition.*

Prepared by a Committee of the American Ornithologist's Union, Ithaca. $8.00. xii + 691 pp. 1957.

An interval of 26 years has elapsed between the 4th and 5th editions of this check-list. Although the geographical scope remains the same, namely, the United States, Canada, Greenland, Bermuda, and Baja California, the number of species and subspecies now recognized has increased from 1420 to 1686. The size of the book has increased by 165 pages, mostly the result of a better delineation of the summer and winter ranges of each form. Each range is outlined with greater precision and with more detail, including casual and accidental records. Other comparisons reveal that the type and format have been improved. Whereas in the earlier edition all subspecies received equal emphasis and each was given a common name, in the present edition the species is emphasized in bolder type and its entire range is described. This heading is followed by the various subspecies, and their respective ranges and their common names have been dropped. Fossil records of modern birds have been included with the range of the species, and the Check-list of Fossil Birds, which appeared as an appendix in the earlier edition, has been omitted. Also left out is a summary of nomenclatural changes, so actually the check-list proper is 275 pages longer than before.

A quick count of changes in scientific names that have occurred in the 26-year interval yielded the following data: 2 ordinal, 2 family, 57 generic, and 48 specific names are different from what they used to be. These alterations reflect an increasing knowledge of avian taxonomy, a change in the concept of the species as a biological unit, and a desire to use the genus to indicate similarities rather than differences. Even at that, not all of the proposed changes have been incorporated into this new list, and I suspect that the next edition will have as many new names in it as the present one. Certainly, taxonomy and nomenclature are not moribund disciplines!

The job performed by the committee in charge has been a painstaking one, and careful workmanship is reflected on every page. Needless to say, this publication is essential for every professional ornithologist, but the amateur bird student can also derive much benefit from its use. Aside from being the standard nomenclatural guide, the information that is provided on distribution is detailed enough that a fairly comprehensive check-list of birds for any part of North America could be derived from it.

HENRI C. SEIBERT

THE LIFE OF MAMMALS.

By J. Z. Young. Oxford University Press, New York and Oxford. $10.00. xvi + 820 pp.; ill. 1957.

One has the impression after reading the title of this book, and then perusing the contents, that the choice of title was influenced more by the author's previous work, *The Life of Vertebrates* than by the innate appropriateness of the title itself. The book is actually an integrated account of the functional gross, microscopic, and developmental anatomy of mammals. Furthermore, it is based primarily, although not exclusively, on the morphology of man, the laboratory rat, and the domestic rabbit, and is intended primarily as a preparatory text for premedical students.

The first chapter introduces the subject matter of the book, and emphasizes the mammalian body as a physical system in homeostasis. This concept of the body functioning so as to maintain a steady state of activity is the basic theme of the book.

The first chapters deal with the skin, various basic tissues, and the body framework and its mechanics. The skeletal framework of the body, and the physics of stress, counterstress, tension, and compression are discussed. It is in this part of the book that mammals of varied sorts are referred to most frequently. In the remainder of the book, which deals with the physiological function and regulatory mechanisms of the internal organs, the material is of necessity drawn mostly from mammals that have been subjected to extensive laboratory study.

The most attractive part of the book, in my opinion, is the careful interweaving of the morphological and the functional. The result is that for each unit completed, the reader has not only surveyed its gross structure, but its histology, physiology, and biochemistry as well. It would be erroneous to suggest that each of these areas is treated as fully as it would be in a textbook devoted to it alone, but finding all of these treated so well in a single volume is indeed exceptional. The text is copiously illustrated, principally by selected illustrations from other authors.

The section on embryonic development comes at the close of the book. Here 5 chapters are devoted primarily to sub-mammalian embryology. While this may seem to diverge from the intended scope of the book, it lays the foundation for a better understanding of the discussion of mammalian development which follows.

In these days of de-emphasis of premedical teaching

per se, it is difficult to see just what segment of the collegiate public this text will serve. Its subject matter is too narrow for a text of comparative anatomy, as it deals only with mammals. It would be a shame indeed, however, if such a comprehensive and well-integrated work were to become merely an ornament to the scholar's bookshelf.

BRYAN P. GLASS

ZOOLOGICAL PHOTOGRAPHY IN PRACTICE. *A Contribution to the Technique and Art of Wild Animal Portraiture.*

By Hugh B. Cott; preface by Julian S. Huxley. Fountain Press, London. 52s. 6d. 370 pp. + 68 pl.; text ill. 1956.

The most attractive part of this book (pp. 220–355) comprises fine examples of zoological photography, with emphasis on tropical life and the great plains of Africa. The corresponding text (pp. 135–203) gives detailed consideration to the combination of artistry and scientific recording, according long chapters to photography of animals in the rain forests, in deserts, and on savannahs. Here Cott has done wildlife photographers a service by pointing out methods he has found useful in tracking interesting animals (from insects to elephants), and in getting them composed against meaningful backgrounds while planning a picture. He is clearly aware of the importance of the ecological setting and has been particularly successful in using his cameras to prove the adaptive nature of animal coloration. Most zoologists will be familiar with his earlier pictures in the semi-classic *Adaptive Coloration in Animals*, which appeared first in 1940. They will be pleased, too, with his plea (and samples) for the use of photographs as the basis for ink drawings. "The arts of photography and drawing are complementary. For while photographs may be used as pictorial aids, drawing in turn teaches us to observe, to compare and select, and to think for ourselves, and so in the long run cannot fail to make us better photographers—and that over the whole range of photographic procedure, from selection of subject and view-point, through development of the negative, to the composition and processing of the exhibition print or lantern-slide."

Pages 204–218 are given over to a tabulated classification of the animal kingdom which, for zoologists, is certainly redundant. Apparently the author aimed his book more at photographers with a casual interest in animals as subjects rather than at zoologists needing to use a camera. The book's title scarcely makes this clear.

An audience "better acquainted with the different breeds of camera than with the various forms of life" will surely be puzzled by the first 134 pages of *Zoological Photography in Practice*. Laudably enough, they are given over to choice of cameras; apparatus and accessories; focusing, depth, and definition; exposure; negatives and development; prints and lantern slides. But almost none of the improved cameras, films, and techniques introduced since 1930 receives even a passing comment. In this, the meat of the book, there is no mention of color photography, coated lenses, light-proof tanks for development, flashbulbs, or electronic flash. Cott vacillates between a twin-lens reflex with roll film and a 4 x 5 inch view camera with glass plates. He seems not to have heard of cut film (sheet film) and sees no alternative to the weight of glass plates (which can be processed one at a time) and the intact role of exposed film (which must be developed as a continuous strip). His discussion of tropical photography has little to say about fungus on lenses and nothing on the use of silica gel or other desiccants to keep film from deteriorating at elevated temperatures. The cine-camera is brushed off with a word, and no space is given to photography of animals except in the field, quite uncontrolled.

The examples of zoological photography, handsome as they are, can be reexamined in the light of Cott's text. Most of them are of creatures which sit quietly for a one-second exposure and demonstrate what fine work is possible by a patient photographer who is willing also to regulate exposure time in enlarging by removal and replacement of a lens cap rather than by use of a switch on the power cord.

In our part of the world (and probably in the United Kingdom too), color slides in the 2 x 2 inch size have completely replaced lantern slides of animals and scenes for current illustrations. And the lot of the zoological photographer has been infinitely lightened in the field by automatic diaphragms, interchangeable backs, electronic flash ("strobe lights"), and reliable commercial processing of color films. In the darkroom he is likely to rely on densitometers, double-coated enlarging paper, and push-button time switches on enlargers.

LORUS J. & MARGERY MILNE

BRITISH MAMMALS.

By Maurice Burton; drawings by Jane Burton. Oxford University Press, London. 11s. 6d. 64 pp.; ill. 1958.

ANIMAL MORPHOLOGY

METHODS FOR OBTAINING AND HANDLING MARINE EGGS AND EMBRYOS.

By D. P. Costello et al. Marine Biological Laboratory, Woods Hole. $3.50. xv + 247 pp. 1957.

What biologist has not wondered during the course of his investigations about using marine invertebrate

embryos as experimental material? Yet until the publication of the present volume no organized body of information has been available concerning the necessary natural history aspects of obtaining, handling, and maintaining marine embryos. This information, often locked within the minds of the few scientists who habitually spend their summers at marine laboratories or who have used the embryos for experimental purposes, has in practice been very difficult to obtain, often necessitating a protracted and often frustrating search through the literature on the animal or group in question.

While the material covered in this book chiefly concerns the embryos of the fauna of the Woods Hole region, many of the species have a cosmopolitan distribution, and much of the information about the handling of the embryonic material of a particular group is transferable to other species. In this respect, most of the phyla are covered, and representatives of several classes are presented for the major phyla. As one would expect, species or groups which have received a relatively large amount of attention from recent experimental workers have been treated more thoroughly than less studied groups, or groups which have not received recent experimental investigations. The references at the end of each section will prove useful to those wishing a more detailed account of the embryology of the species in question.

This book fills a badly needed niche in the form of an organized reference work on marine embryos. It should be invaluable to students and seasoned investigators alike.

R. R. COWDEN

A LABORATORY MANUAL FOR INSECT MORPHOLOGY. *By E. H. Strickland, B. Hocking, and G. E. Ball. Scholar's Library, New York.* $3.50 (paper). xii + 81 pp.; ill. 1958.

OVARIAN MORPHOLOGY AND EARLY EMBRYOLOGY OF THE PEDICULATE FISHES *ANTENNARIUS* AND *HISTRIO*. *Bull. Amer. Mus. nat. Hist., Vol. 114, Art 4.*

By Priscilla Rasquin. American Museum of Natural History, New York. $1.50 (paper). Pp. 327–372 + pl. 47–74; text ill. 1958.

ANIMAL PHYSIOLOGY

RECENT ADVANCES IN INVERTEBRATE PHYSIOLOGY. *A Symposium.*

Edited by Bradley T. Scheer and three associate editors. University of Oregon Publications, Eugene. $5.50. vi + 304 pp.; ill. 1957.

This is a collection of papers presented at a symposium designed to afford invertebrate physiologists an opportunity to become better acquainted personally and to exchange ideas. Some of the papers are reviews; others are research reports. Two papers presented at the meeting were not included. The following list indicates the papers and the scope of the symposium: Neuronal Integrative Mechanisms (T. H. Bullock); Diurnal Migration of Plankton Crustaceans (E. R. Baylor and F. E. Smith); Prey-Predator Recognition in the Lower Invertebrates (L. M. Passano); Prey Capture in Mantids (H. Mittelstaedt); Nervous Control of Insect Muscles (G. Hoyle); Myogenic Rhythms (J. W. S. Pringle); The Machinery of Insect Flight (E. G. Boettiger); Neuromuscular Mechanisms (C. A. G. Wiersma); Neurohormones or Transmitter Agents (J. H. Welsh); Endocrinology of Invertebrates, Particularly Crustaceans (L. H. Kleinholz); Humoral Dependence of Growth and Differentiation in Insects (D. Bodenstein); The Hormonal Control of Metabolism in Decapod Crustaceans (B. T. Scheer); Osmotic and Sonic Regulation in Aquatic Invertebrates (J. D. Robertson); Recent Advances in Knowledge of Invertebrate Renal Function (A. W. Martin); Some Features of the Physiology of the Tunicate Heart (B. J. Krijgsman and N. E. Krijgsman); and The Rhythmic Nature of Life (F. A. Brown).

The selection of topics gives a fairly good representation of active areas of research at the present time. The most outstanding omission is sensory physiology. It is particularly regrettable that the field of vision was not represented, since currently this is an active area of research. However, the collection of papers is a valuable one. The planners of the symposium are to be congratulated upon including such a fine representation of European workers.

V. G. DETHIER

COMPARATIVE PHYSIOLOGY OF THE NERVOUS CONTROL OF MUSCULAR CONTRACTION.

By Graham Hoyle. Cambridge University Press, New York. $3.00. viii + 147 pp.; ill. 1957.

This monograph, Number 8 of the Cambridge Monographs in Experimental Biology, covers a rather narrow, but very important, area of biology. It begins with a review of organization of the muscle cells and of the histology of nervous innervation in the different phyla. Many of the histological studies are quite old and contradictory, a fertile area for the electron microscope. There follow chapters on the electrical properties of the membranes of resting muscle cells, the muscle action potential, and the endplate or junction potential. Hoyle reviews the important recent advances on these areas; this is, in fact, one of the first textbooks to incorporate these new data. Neuromuscular phenomena are discussed, through the phyla, following, whenever possible, a set of principles based on the review of membrane phenomena. In this section Hoyle draws heavily

on his own extensive investigations. The basic myoneural apparatus is strikingly similar through the phyla; the result of evolution has been the transfer of the control of the musculature from local regions to the central nervous system. The monograph closes with a succinct survey of the problem of the coupling of membrane potential changes and contraction. To resolve this problem, the author suggests a surface reaction, whose electric effects are likely to be masked by the action potential. Without further hints as to the properties of the reaction, there seem to be no obvious physical methods of studying it.

The author has succeeded in covering competently the area he chose and has had some success in correlating the experimental results with fundamental ideas on membrane processes. One is forced to criticize, however, the omission of reference to American investigators on several occasions where American and Britons were independently reaching the same results.

CHARLES EDWARDS

RECENT PROGRESS IN HORMONE RESEARCH. *Vol. 13. Proceedings of the Laurentian Hormone Conference 1956. Edited by Gregory Pincus. Academic Press, New York.* $12.80. viii + 646 pp.; ill. 1957.

The high standard of presentation found in the earlier volumes of this series is maintained and very likely surpassed by the present volume. Five major problems currently under active investigation in endocrinologic research are discussed in this book. The first section, Neurohumoral-Endocrine Relationships, includes 4 articles: Biochemical, Physiological, and Pharmacological Aspects of Serotonin (Udenfriend, Shore, Bogdanski, Weissbach, and Brodie); The Effects of Midbrain and Spinal Cord Transection on Endocrine and Metabolic Functions with Postulation of a Midbrain Hypothalamico-Pituitary Activating System (Anderson, Bates, Hawthorne, Haymaker, Knowlton, Rioch, Spence, and Wilson); Studies on the Influence of the Central Nervous System on Anterior Pituitary Function (Greer); and Hormones and Rhythms in Man and Animals (Richter). Section II deals with Hormone Transport in Circulation. The 2 papers in this section are: The Interaction of Thyroid Hormones and Protein in Biological Fluids (Robbins and Rall); and The Binding of Steroids and Steroid Conjugates to Human Plasma Proteins (Sandburg, Slaunwhite, and Antoniades). Section III is devoted to Aspects of Reproduction. It includes 4 articles: Some Experimental Studies on the Mechanism of Ova-Implantation in the Rat (Shelesnyak); Synthetic Progestins in the Normal Human Menstrual Cycle (Rock, Garcia, and Pincus); The Metabolism of Progesterone and Its Clinical Use in Pregnancy (Davis and Plotz); and Long-Acting Steroids in Reproduction (Junkmann). Section IV discusses the recent work on Hormone Chemistry and Metabolism, with 2 papers: Insulinase, Insulinase-Inhibitors, and Diabetes Mellitus (Mirsky); and Glucagon, A Second Pancreatic Hormone (Foà, Galansino, and Pozza). Section V describes 2 aspects of Hormones and Stress. The papers presented are: Endocrine Changes after Anesthesia, Surgery, and Unanesthetized Trauma in Man (Moore); and Adrenal Influences upon the Stomach and the Gastric Responses to Stress (Gray and Ramsey).

As in the previous volumes, each formal presentation is followed by a critical discussion of the material by recognized authorities in the field of endocrinology. These discussions are highly stimulating and add substantially to the value of the book.

SHERWOOD M. REICHARD

THE PHYSIOLOGY OF FISHES. *Vol. 2. Behavior. Edited by Margaret E. Brown. Academic Press, New York.* $14.00. xi + 526 pp. + 8 tables; ill. 1957.

In any expanding field of investigation, a great need arises at intervals for someone to summarize what is known, to contrast discrepant reports, and to indicate the major gaps in knowledge. The task requires Solomon-like judgment to separate the kernels from the chaff, the studies in depth from the superficial, the well-controlled experiments from those too hastily contrived.

The need for an effort of this kind on the physiology of fishes has become increasingly acute in recent years. Surely a competent review of the extensive literature would reveal common denominators of significance. Yet who could feel ready to survey adequately so broad a field? It is greatly to the credit of editor Brown that she was able to obtain the productive cooperation of nearly two dozen key scientists, each willing to set aside a research program, view the literature with as much perspective and emotional detachment as possible, and bring the record up to date. The first in this two-volume summary was here reviewed (*Q.R.B.*, 32: 300. 1957) as constituting the work of 8 collaborators on metabolism of fishes.

The present volume covers nervous coordination, receptors, effectors, and a few miscellaneous topics (biochemistry of pigments, physiological genetics, and the limitations of fish in tolerating adverse conditions of "water quality"). Of the 14 authors, the larger proportion are from America (Aronson, Doudoroff, Fox, Gordon, Harvey, Hasler, and Odiorne from the U.S.A.; Brett from Canada). Those from the Old World include Baerends from Holland; Bull, Healey, Harden Jones, Keynes, and Lowenstein from the United Kingdom.

One might assume that the third of all vertebrate species lumped as "fish" would be rather uniform in function, perhaps reflecting in their evolution some of the inertia of the watery medium. The facts prove the contrary, showing the field of fish physiology to be sur-

prisingly full of scientific challenges. Even the lack of any true cerebral cortex—a feature of the fish brain—does not prevent localization of "initiative" in obviously simpler, homologous areas. In fact, the whole detailed parallel account by E. G. Healey on anatomy and experimentally demonstrated function in the central nervous system engenders a respect for the potentialities at this lower level of organization. The later chapters or parts on conditioned responses (H. O. Bull), general behavior (G. P. Baerends), and reproductive and parental behavior (L. R. Aronson) reinforce this view.

The division of the subject field among the several collaborators was bound to lead to strange bedfellows. Some of the striking discoveries on sound-production and hearing in fish appear in F. R. Harden Jones' account of the swimbladder (Chapter IV) rather than in O. Lowenstein's review of the acoustico-lateralis system (Chapter II: part 2). The late Francis Sumner's work on color changes in flounders is noted briefly in D. L. Fox's biochemical survey of pigments occurring in fish (Chapter VII) rather than in the subsequent chapter on color changes, organized by J. M. Odiorne. And although the six extrinsic muscles of the fish eye are mentioned, response to movements in the visual field discussed, and orientation in the water considered in relation to nests, the intriguing subject of the eye's gyroscopic stability is bypassed—in the very class of vertebrates where it is most spectacularly developed. A fish sees its world (albeit often poorly) from more angles—head up, head down—than most animals, and this affects both its anatomy and behavior.

The final long chapter on physiological genetics draws together an amazing range of information "the complete details of which are as yet unknown," though nonetheless fascinating. Fishes apparently provide one of the happiest hunting grounds for unusual features in inheritance, as, for example, the platyfish *Xiphophorus maculatus* in geographical races of which sex follows the course of XX female, XY male (4 separate Mexican rivers) or WY female, YY male (a river in British Honduras). Myron Gordon concludes from this dual system in a single species that "the mode of evolution of the dual genetic mechanisms for sex determination in vertebrate animals may eventually be solved by careful study of sex linkage in the poeciliid fishes." Nearly 15 pages are well spent in reviewing the information on the formation of melanomas after hybridization of still others among the common fish of tropical aquaria. Investigation of carcinogenesis seems open to many scientists for whom the keeping of tropical fish is both a pleasure and a research interest. Certainly the facilities required are far less extensive than those for the study of cancers in mice.

This 2-volume work is filled with stimulating suggestions, half-answered questions, and references to the literature well into the current decade. It should be on the shelf of every fisheries biologist, and on the reading list of all comparative physiologists and biochemists. Surely it will encourage much new investigation.

LORUS J. & MARGERY MILNE

ANIMAL NUTRITION

A HISTORY OF NUTRITION. *The Sequence of Ideas in Nutrition Investigations.*

By Elmer V. McCollum. Houghton Mifflin Company, Boston. $6.00. x + 451 pp. 1957.

Elmer V. McCollum, one of the truly great contributors to the science of nutrition, has devoted much of his time during the past ten years to compiling this work. The result is an authoritative history of ideas in the field of nutrition, written in an eminently readable style. The book is a source of valuable background material to the specialist and provides a fascinating account of the development of scientific thought for the non-specialist. The author has done a gigantic job, delving into thousands of dusty tomes to bring to light the history-making ideas concerning food requirements, dating back to ancient times and reaching into the modern era through the year 1940. Here we find observations by Herodotus on the role of sunlight in bone formation, a recommendation by Hippocrates of the use of cod liver oil for night blindness, and an excellent description by Goethe of the symptoms of pellagra as observed by him in his travels through Italy.

These examples are all taken from the early history of the discovery of the vitamins. Similar examples could be chosen concerning the role of fats, carbohydrates, proteins, or minerals. The more recent history includes, for each substance, a lively step-by-step account of the major scientific advances which led to its evaluation as a nutrient. The importance of chemical studies, of clinical observations, and above all, of the use of experimental diets for the production of specific deficiency symptoms in animals are all carefully documented.

McCollum was himself a pioneer in the development of experimental diets, which led him to the discovery of vitamin A and to important contributions to our knowledge of the vitamin B complex, vitamin D, and vitamin E, as well as of mineral nutrition. Being blessed also with great breadth of vision and an engaging literary style, he was thus uniquely qualified for the task which he has accomplished so brilliantly.

SIDNEY P. COLOWICK

SYMPOSIUM ON NUTRITION AND BEHAVIOR. *Proceedings of a Symposium held at the University of Minnesota, School of Public Health, Laboratory of Physiological Hygiene, Minneapolis, Minnesota, April 27, 1956, 14.*

Edited by J. Brozek; 26 contributors. The National

Vitamin Foundation, New York. $2.50. 123 pp. 1957.

The 22 papers collected here fall into three categories: the impact of diet on behavior; hunger and appetite; and satiety and weight control. For the most part these papers represent original work of the divers authors, and are integrated to some degree with the general category or chapter in which they appear. For the scientist who wishes to learn at a glance the current status of experimental work in nutrition and behavior, this collection of papers will be extremely useful.

V. G. Dethier

BIOPHYSICS AND GENERAL PHYSIOLOGY

Radiation: What it is and How it Affects You. *By Jack Schubert and Ralph E. Lapp. The Viking Press, New York.* $3.95. 314 pp. 1957.

"The educational process required to indoctrinate people as to the nature of nuclear war constitutes an immense challenge to the ingenuity and daring of every nation." This statement appears in Chapter 10 of *Radiation* and is indicative of the formidable task the authors have taken upon themselves in presenting, for the enlightenment of the public, a comprehensive survey of the nature of radiation, its uses, and its effects. Schubert and Lapp have achieved only moderate success. In the early chapters there is an interesting historical treatment from the discovery of x-rays to the bombing of the Japanese cities. Unfortunately, this kind of development was abandoned by the authors, rather quickly to be replaced by an endless series of case histories. Case histories can make fascinating and informative reading, and some of these do, but there is a plethora of them. The technical information about the nature and origin of radiation is scattered too freely to be comprehensible to the non-scientist.

The book treats, in this order, the hazards of radiation used for medical purposes; the radiation syndrome; the alarming lack of knowledge on the part of many physicians, dentists, and technicians who use radiation routinely; radioactive isotopes and their uses; accidents occurring in atomic laboratories; the irradiation of children; hereditary effects; legal problems arising out of faulty use of radiation fallout; and the final two chapters, on The New Nature of War and on Safeguards for the Future. A useful glossary of technical terms and a bibliography appear at the back of the book; at the front and back are detachable sheets for the recording of irradiation received by the individual for medical purposes.

Although the authors have attempted to examine many aspects of the radiation problem, and present both its benefits and its terrors, they appear to be carrying a large sign with the word BEWARE printed upon it. As Schubert and Lapp have indicated, the public must be made aware of the dangers of radiation in all its ramifications, but the approach should not lean so heavily on startling the reader.

There is some valuable and enlightening material in the book which makes it worthwhile as a reference work. However, the style and organization will make it difficult for the lay reader.

Schubert and Lapp make some recommendations of their own concerning the safe use and control of radiation. They suggest that the facts about radiation should be made available for public consideration and proper evaluation of the biological hazards of our atomic era, that the program of research in the areas of radiobiology should be continued with renewed vigor, that a program for the study of "actual human experience with radiation injury" should be initiated, perhaps by a government agency, that national legal standards for radiation exposure ought to be established, and, in line with this proposal, that the limit of dosage should be reduced to .1 r per week and 5 r per year, for occupationally exposed adults. There can be no quarrel with these recommendations.

Norman S. Cohn

Radiological Physics. *By M. E. J. Young. Academic Press, New York.* $7.50. x + 365 pp.; ill. 1957.

This textbook, designed for radiologists and hospital physicists, deals with the physical techniques utilized in diagnostic and therapeutic radiology. The over-all choice of material appears sound and the style is clear. Illustrations, graphs, and tables are numerous and useful. Well-chosen examples of radiological applications are described in detail. On the other hand, the presentation of the principles of the physical and biological action of radiation seems rather weak. Adequate space is allotted to the basic phenomena, on the whole, but its distribution is spotty. For example, the theory of the classical scattering of x-rays is developed in some detail, but the main process of x-ray production is treated only incidentally to a description of the spectral distribution by a few vague and misleading statements such as the following: "[The continuous spectrum] is emitted by the impinging electrons themselves as they are retarded [?] on striking the target. ... Most of the electrons ... strike the targets in such a way [?] as to convert only a part of their energy into x-ray photons." Ten pages are devoted to nuclear energy and reactors, as an introduction to isotope techniques. Today, and within the scope of this book, it should be possible to provide the student with a more real and balanced understanding than his elders received when the subject matter was new.

U. Fano

BIOCHEMISTRY

THE ANALYTICAL USES OF ETHYLENEDIAMINE TETRAACETIC ACID.

By Frank J. Welcher. D. Van Nostrand Company, Toronto, New York, and London. $8.50. xvii + 366 pp. + 35 tables; ill. 1957.

Ethylenediamine tetraacetic acid, one of the major chelating agents, has proved to have many important applications in organic chemistry, biochemistry, and medicine. It is used extensively for inhibiting unwanted catalytic effects, and it is a valuable tool for enzymologists, particularly for controlling the effects and concentrations of various metal ions. It has a number of uses in medicine, particularly in the treatment of poisoning by certain heavy metals. This treatise has a very important value in that it is an excellent reference for most of the significant work done on the application of EDTA in organic analyses. The author has given considerable attention to the content of the most significant work published on end-point determination and EDTA titration; the requirements, uses, theories, and types of metal indicators employed in such determinations; and the analyses of cations in mixtures as well as of water hardness. As would be expected, he covers in great detail the methods for the determination of various metal ions and anions, and organizes this material according to the logical groupings of these substances. This valuable reference has an extensive bibliography and should prove to be a great time-saver for those who desire to apply EDTA to a particular analytical problem.

DAVID B. TYLER

SYNTHETIC POLYPEPTIDES. *Preparation, Structure, and Properties. Physical Chemistry: A series of Monographs.*

By C. H. Bamford, A. Elliott, and W. E. Hanby. Academic Press, New York. $10.00. xiii + 445 pp.; ill. 1956.

Three very active investigators in this field have collaborated to produce this up-to-date and authoritative discussion of the chemistry of synthetic polypeptides. The subtitle of the book aptly describes the breadth of the material covered. The methods and mechanisms of the syntheses of polypeptides are first reviewed. A thorough discussion of the various helical structures precedes the results obtained from the methods (infrared spectroscopy and x-ray diffraction) used to demonstrate these structures. The chapters on the results obtained by these techniques follow an introduction to the method. Special topics in infrared spectroscopy deal with dichroism and hydrogen bonding. A chapter devoted to the properties of synthetic polypeptides includes such topics as their dyeing properties, optical rotation, molecular weight determinations, and solubilities. Two tables summarize the information on their molecular weights, solubilities, and the preparative data for individual polypeptides. S. G. Waley reviews the biological properties of these substances. The last chapter is concerned with the structure of fibrous proteins, silk, and keratin. The text is documented with reference to the original literature, including citations to publications in 1956. This book is a necessary addition to the bookshelf of anyone interested in the chemistry and structure of polypeptides, linear polymers, and proteins.

LEOPOLD MAY

ÉLÉMENTS D'IMMUNOLOGIE GÉNÉRALE.

By P. Gastinel, R. Fasquelle, and P. Barbier. Masson & Cie., Paris. 2,000 fr. (paper.) viii + 335 pp.; ill. 1955.

This immunology textbook consists of 12 sections which include such topics as plasma proteins, complement, properties and reactions of antigens and antibodies, and cellular and tissue phenomena associated with immunity and hypersensitivity. The book has been written with an emphasis on the medical aspects of immunology, and the authors have surveyed a considerable amount of material in this area. There is an index, and an adequate bibliography is listed at the end of each chapter. The material is clearly presented, and the book could serve satisfactorily as a reference work for medical students or intermediate graduate students in biology.

S. R. SUSKIND

INTRODUCTION TO ENZYMOLOGY.

By Alan H. Mehler. Academic Press, New York. $10.80. viii + 425 pp. + 8 tables; ill. 1957.

The book contains chapters on the Hydrolysis of Peptides and Proteins, Fermentation and Oxidation of Major Metabolic Fuels, Biological Oxidation, Sugars and Sugar Derivatives, Polynucleotides and their Components, Amino Acids, and Acids and Acid Derivatives. In addition to describing the properties of individual enzymes, the author places considerable emphasis on the "interrelations of enzyme activities, the chemical mechanisms employed by biological systems, and the multiple factors to be considered in interpreting biological data." The final chapter, on the Organization of Structure and Function, is devoted to a discussion of the complex problem of integrating enzyme systems with cellular structure and function.

The subject matter is remarkably free of errors, logically presented, and lucidly written. Statements in the text are extensively documented by references at the foot of the page. In addition, general references are included at the end of each chapter.

This volume should be of great value to both the student and research worker in biochemistry and related fields. For the student, it provides a sound introduction to the field of enzymology, and for the research worker, a welcome summary of the present status of a rapidly developing field.

JOHN GIOVANELLI

BIOCHEMICAL DISORDERS IN HUMAN DISEASE.

Edited by R. H. S. Thompson and E. J. King. Academic Press, New York. $12.60. xiv + 843 pp. + 13 pl.; text ill. 1957.

The current rate of accretion of new information concerning the pathogenesis and treatment of disease puts us all in the position of Alice and the Red Queen. When Alice, gasping for breath, complained that the speed with which she ran had allowed her only to maintain her original position, the Queen replied that in order to get anywhere she would have to run twice as fast. Nowhere in the biological sciences is this so true as in biochemistry, where rapid advances keep the physician, busy as he is with the day's problems of diagnosis and treatment, in perpetual bewilderment. If he would stay abreast he must read a great many journals and correlate for himself a large volume of information. It is evident that the editors and authors of this excellent book had in mind this problem when they undertook their task. As they have indicated in their Preface, they have attempted to provide an understanding of disease in terms of alterations in cellular metabolism, illustrating clearly the swing away from the traditional morphological pathology to a more dynamic, biochemical, and physiological pathology. This is well exemplified in the table of contents, in which the chapter headings consist in part of the classical type, such as Diseases of the Nervous System, and in part of others which defy this kind of classification and so have had to be entitled, Miscellaneous Disorders of Metabolism. This dilemma indicates a transitional stage in medical taxonomy due to new understanding of human biology.

This book was written by 31 authors, each an expert in his field, and about 4500 references are cited. These statistics indicate the dimensions of the task the editors have undertaken, and an adequate review of the work could probably be done only by an equally competent staff of reviewers.

It is obvious that not all the disorders dealt with can be discussed on the same biochemical level. For example, much of the chapter on hypertension is concerned with essential hypertension. Not much is known about the biochemical basis of this condition, but the author of this chapter has suggested areas where research is needed. Another level of biochemical information is reached in the chapters on the Lipoidoses and Connective Tissue Diseases, in which evidently a good deal is known about the substances involved, but relatively little about the steps in their synthesis and metabolism. Perhaps the highest level is obtained in the chapters devoted to disorders of carbohydrate metabolism, in which much is known of the intermediate compounds involved, their ultimate disposition, and the enzymes that catalyse the reactions. To point out these disparities is not to criticize, but to indicate that the authors have taken a very broad view and have not been afraid to discuss business which is not only unfinished, but indeed scarcely begun.

There are several chapters on diseases of blood formation, the clotting mechanism, and iron and hemoglobin metabolism. These are excellent chapters and show the stake the hematologist of today has in chemistry. A long chapter on renal disease reflects the wide knowledge of the physiology of the kidney, but only the beginning of an understanding of its biochemical mechanisms. The rapid strides in endocrine research of the last few years are reflected in 5 comprehensive and up-to-date chapters dealing with the chemical effects of various hormones, together with, in some instances, techniques of measurement and assay. A chapter dealing with disease of the nervous system reveals the trend away from classical functional neurology to an understanding of neurological disorder in terms of biochemical abnormality. This is perhaps one of the least developed and most hopeful fields for investigation. A large number of nervous disorders exist, usually carrying a hopeless prognosis and usually much discomfort and disability. One of the major problems for physicians and society at large is the problem of mental defect, sometimes genetic in origin, sometimes associated with intrauterine disease, or perinatal conditions. When these abnormalities can be seen in their chemical perspective, much will have been gained. An especially good feature of this chapter is an introductory section entitled General Biochemical Considerations, in which the special metabolic features of nervous tissue are outlined. A long and well-organized chapter on diseases of muscles reveals that a great deal more of a biochemical nature is known about this tissue than most physicians suspect. A chapter on abnormalities of amino acid and hemoglobin metabolism was a fortunate choice, if for no other reason than that emphasis is placed upon the genetic origin of most of these conditions. It is evident that a great deal more information is needed about the genetic sources of human variability and that a considerable impetus has been given to this field through the study of the aminoacidurias as well as the hemoglobin variants.

Altogether this is a most useful book. It is an excellent source of background material if one needs information on a specific topic, or if one would fill in gaps in his knowledge in a more general area. All the chapters are not of equal quality in either a literary sense or in summarizing the topic under scrutiny. But to my mind the editors and authors have fulfilled their aims and have done an important service. The physician who

possesses this book will have at hand an up-to-date reference library containing a wealth of information not readily available to him in any other single place.

BARTON CHILDS

FORTSCHRITTE DER CHEMIE ORGANISCHER NATURSTOFFE. *Volume 14.*

Edited by L. Zechmeister. Springer-Verlag, Wien. $16.90 (paper); $17.85 (cloth). viii + 377 pp.; ill. 1957.

This volume, like its predecessors, deals again with a number of interesting subjects. Bohmann and Mannhardt (Braunschweig) describe the numerous acetylene derivatives discovered recently in higher plants, oils, and molds, and speculate on their biosynthesis from acetyl-coenzyme A. Acetyl-coenzyme A seems also to be the precursor of some of the natural phenols and enols, as shown in the chapter of A. J. Birch (Manchester). Biologists will be particularly interested in the sections which deal with the biosynthesis of lignin, flavonoids, anthocyanins, and tropolones. The cardiac glycosides are treated by Ch. Tamm (Basle), whose contribution contains 25 pages of tables on the physical and chemical properties of the glycosides, their aglycons and sugars. H. Brockmann (Göttengen) discusses chiefly his own work on the photosensitizing plant pigments, hypericin and fagopyrin. The chemistry, physiology, and pharmacology of the aminochromes, colored oxidation products of adrenalin, and other phenylethylamine derivatives are treated in a short chapter by H. Sobotka et al. (New York). The carbon cycle in nature is the subject of an interesting chapter written by H. Brown (Pasadena). In addition to photosynthesis and oxidation, the equilibration of carbon dioxide with water, with carbonate sediments, and with magnesium silicate is discussed. The reader will find interesting data on the equilibration between terrestrial, oceanic, and atmospheric carbon, and also data on carbon in the universe and on the primitive earth. Biologists and physiologists will be particularly interested in the chapter on visual pigments, written very clearly and critically by Morton and Pitt (Liverpool). The authors emphasize the great difficulties encountered in the isolation of these photosensitive, labile pigments, and the gaps which still exist between physiological and chemical data.

F. HAUROWITZ

MICROBIOLOGY

THE CHEMISTRY AND BIOLOGY OF YEASTS.

Edited by A. H. Cook. Academic Press, New York. $22.00. xii + 763 pp. + 3 pl.; text ill. 1958.

The rapidly increasing use of yeasts in modern biological research and their continued economic importance promise to provide an eager audience for the thoroughgoing résumés contained in this volume. While research and technological interests have dictated that stress be laid on the Endomycetaceae (yeasts whose life cycles include both sexual and asexual reproduction), several discussions range quite far beyond this group of organisms. In some cases these digressions are beneficial but, more often, they tend to shield the fact that in many areas our knowledge of yeasts is still rudimentary or completely lacking.

In keeping with the modern trend, each chapter is written individually. This has facilitated rapid publication and provided competent examination of special topics. Discussed are yeast classification, distribution (termed "ecology"), life history, cytology, genetics, chemical composition, growth, fermentation, respiration, cellular carbohydrates, and nitrogen metabolism. Yeast technology, pathogenesis, and food spoilage are surveyed in later chapters. A final chapter, on flocculation of yeasts, although interesting in itself, is a bit out of place in this volume.

There are three great shortcomings which a multiple-author volume of this type faces if an integrated, cohesive, and comprehensive picture is to be presented. The first shortcoming lies in duplication, the second in failure of integration. These two defects often go hand in hand. The third shortcoming lies in outright omission of important topics. In this volume, the editor has preferred to let individual autonomy reign supreme. For example, there are several brief sketches of cell wall structure and composition which could have been brought together and, with but little extension, converted into a meaningful synthesis. Further, there is no adequate discussion of a number of topics, such as phosphorus metabolism and polymetaphosphates, or of studies concerning the permeability of the yeast cell.

Certainly this book is timely and a valuable guide to the present status of the yeasts and their properties. Its very excellent index makes specific information readily available. Nevertheless, one might have hoped that a volume which reflects the earnest endeavours of a number of excellent scientists might have much more than temporal value.

PHILIP E. HARTMAN

LABORATORY MANUAL FOR DAIRY MICROBIOLOGY.

By E. M. Foster and W. C. Frazier. Burgess Publishing Company, Minneapolis. $2.50 (paper). 62 pp. 1957.

HEALTH AND DISEASE

THE PHYSIOLOGY OF INDUCED HYPOTHERMIA. *Proceedings of a Symposium convened by the Division of*

Medical Sciences, Nat. Acad. Sci.—Nat. Res. Coun., with the sponsorship of the U. S. Army, Navy, & Air Force.

Edited by Robert D. Dripps. National Academy of Sciences—National Research Council, Washington. $3.50. xiii + 447 pp.; ill. 1956.

For those interested in the physiology and biochemistry of hypothermia, whether in active research or merely with the wish to satisfy an intellectual curiosity, this symposium presents a valuable and extensive review of the subject in experimental and medical practice. The symposium comprises 42 separate papers in five areas: general physico-chemical and physiological considerations; the effects of hypothermia on specific systems; myocardial irritability in hypothermia; clinical applications; and techniques of inducing hypothermia. Following, but appropriately subordinate to, certain of the more provocative papers, is a transcription of the discussion of the work. Unlike many published conferences, care has been taken to keep the discussion from interfering with the continuity of the paper. Further, each section has been summarized and critically appraised by others familiar with the field, so as to provide a valuable aid to readers unfamiliar with the subject if of academic interest to others working with it.

Hypothermia is of great interest today as a promising means for treating shock and for reducing metabolism prior to cardiac surgery. Yet at present its application is not without danger, particularly to the heart and central nervous system. The mechanisms by which hypothermia acts to induce the fibrillatory reaction in cardiac muscle and to lower the central nervous system threshold to seizure probably arise from the hypometabolic state itself. Thus, a means of controlling such undesirable reactions as *p*H change, potassium and other ionic shifts, and depression of the hemopoietic system must be found before hypothermia can be used with impunity. These and many other problems relating to the reduction of body temperature have been thoroughly discussed in the symposium, and this book may very well serve as the current handbook on the subject.

THOMAS E. NELSON, JR.

WOMEN OF FORTY

By M. E. Landau. Philosophical Library, New York. $2.50 49 pp. 1956.

This book is a very brief, authoritative, and direct discussion and interpretation of the symptoms and discomforts of menopause. Though the undersigned lacks the proper sex and age to evaluate this book satisfactorily, he can say, after reading it, that he is tempted to conclude that this dreaded curse of womanhood is merely a pause that refreshes.

THOMAS E. NELSON, JR.

THE LEUKEMIAS: *Etiology, Pathophysiology, and Treatment. Henry Ford Hospital International Symposium.*

Edited by John W. Rebuck, Frank H. Bethell, and Raymond W. Monto. Academic Press, New York. $13.00 711 pp.; ill. 1957.

This book brings up to date an excellent review of the achievements in the field of the study of leukemia. This volume accomplishes 2 purposes. It presents in one excellent reference book the present complex picture of known facts and theories relating to the pathophysiology and etiology of leukemia, and establishes a basis of comparison with the earlier works dealing with it. Thus, the reader can see that there has been a significant progress in the study of this discouraging disturbance.

The authors of the various papers included in the volume have been chosen for their authority in their respective fields from the United States and Europe. The book is full of information of value to anyone interested in leukemia research and treatment. The material is thought-provoking, and suggests the many pathways open for future study of challenging problems.

The book is presented in eight parts: Part I, The Leukemia Cell: its Structure and antigenicity; Part 2, Genetic and Environmental Factors in the Transmission of Leukemia; Part 3, Radiation Biology of Leucocytes; Part 4, Leukemias and the Malignant Lymphomas; Part 5, Leucocytic Physiology; Part 6, Metabolism of Amino and Nuclear Acids in the Leukemias; Part 7, Further Biochemical Considerations in the Leukemias; Part 8, Nucleic Acids as a Target for Chemotherapy; Mechanisms of Drug Action and Resistance. Each of these various parts is divided into appropriate chapters discussing individual problems pertaining to the general headings of the separate sections.

For the clinician interested in therapy, the last 11 chapters will be found particularly interesting. For, in these 70 pages, will be found all that is known in present day therapy of leukemia. In Part 2, presented concisely, is the entire complex theory as to the possible viral etiology of leukemia. This is a particular field that is receiving a great deal of attention today.

ROBERT G. CHAMBERS

THROMBOELASTOGRAPHY. *American Lectures in Pharmacology.*

By Pietro de Nicola. Charles C Thomas, Springfield, Ill. $5.50. x + 110 pp.; ill. 1958.

By means of an ingenious, relatively simple device, the thromboelastograph, the changing elasticity of plasma or whole blood can be measured and recorded as a clot forms. Dissolution of the clot can also be followed. The author, an Italian hematologist, describes the instrument and, after brief consideration of its action and use, describes its application as an objective method for the over-all evaluation of coagulation. Adequately illus-

trated are the use of the thromboelastograph in the laboratory investigation of blood clotting and in characterizing the clotting defect in a number of clinical settings.

The instrument has been used with the blood of hemophiliacs, in diseases involving platelet alterations during anticoagulant therapy, and in several other instances following the administration of therapeutic agents. The author presents his findings by means of numerous reproductions of thromboelastograms and graphic depiction of the records. The alterations shown are related to basic mechanisms of coagulation as a part of the author's development of his theme.

The book is one of the American Lecture Series and should be interesting to those who wish a brief introduction to this method of analysis of coagulation and its alterations in health and disease.

J. FREDERICK JOHNSON

DOCUMENTA OPHTHALMOLOGICA. *Advances in Ophthalmology. Vol. IX, Fasc. 1 and 2.*

Edited by G. von Bahr, J. Ten Doesschate, H. Fischer-von Bünau, J. François, H. Goldmann, G. Lo Cascio, H. K. Muller, Jean Nordmann, A. J. Schaeffer, and Arnold Sorsby. W. Junk, The Hague, Netherlands. Dutch guilders 60. (1) 208 pp. + 8 pl.; text ill. (2) iv + pp. 209–424; ill. 1955.

This is a collection of 6 papers dealing with some special visual problems. The authors and titles of their contributions are: E. Bürki, Über das Cylindrom der Meibomschen Drüsen; S. Kretzschmar, La fausse correspondance rétinienne; K. Motokawa, Color contrast and physiological induction in human and mammalian retinas; E. N. Willmer, A physiological basis for human color vision in the central fovea; R. Weekers, E. Prijot and Y. Delmarcelle, Indications, résultant de leur mode d'action, des divers traitements médicaux et chirurgicaux de l'hypertension oculaire; and J. François, G. Verriest, and A. de Rouck, L'achromatopsie congénitale.

The first paper, on tumors of the Meibomian glands, and the fifth, on ocular hypertension, are primarily of ophthalmological interest; the others are of more general physiological interest. Kretzschmar, for example, reports extensive observations on binocular vision and anomalous retinal correspondence. Motokawa reports that electrical excitability studies on the eyes of humans and cats reveal similar contrast and inhibition effects. Willmer presents a review of the facts concerning the color blindness of the central fovea and suggests some physiological mechanisms which could account for such findings. François and his colleagues have prepared a useful summary tabulation of the 247 cases of total color blindness which have been reported in the scientific literature, and then report data on three cases of their own.

A. CHAPANIS

NEW ANSWERS TO THE FATIGUE PROBLEM.

By Adelaide K. Bullen. University of Florida Press, Gainesville. $4.50. xii + 176 pp.; ill. 1956.

New Answers to the Fatigue Problem is an analysis of the people working in industry, their reactions to usual strains and tensions (noise, eyestrain, etc.), and their response to improvements directed toward enhancing working conditions and work output. Although the author has presented some valuable information from the standpoint of industrial management and manpower screening, the book is not well-written. The text is monotonously presented in the first person, and the reader is taken through a series of chatty interviews and descriptions of working conditions and comments of employees. This is further complicated by an attempt to classify, by phenotype, the various reactions of the individuals studied. The subject is certainly one of importance. Studies such as this one can materially aid both employer and employee, and it is unfortunate that this information was not presented in a more concise, less fatiguing fashion.

THOMAS E. NELSON, JR.

PSYCHOLOGY AND ANIMAL BEHAVIOR

DISCUSSIONS ON CHILD DEVELOPMENT. *Two Volumes. Proceedings of the First Meeting of the World Health Organization Study Group on the Psychobiological Development of the Child, Geneva, 1953, and of the Second Meeting, London, 1954.*

Edited by J. M. Tanner and Barbel Inhelder. International Universities Press, New York. $10.00. (I) 240 pp.; ill. (II) 271 pp. + 4 p.l 1957.

It would be hard to imagine a more interesting pair of volumes for the reader interested in new approaches to the scientific study of child development. It is a common belief that the most rewarding portion of a scientific meeting is the informal discussion that goes on outside the formal sessions, in hallways, hotel rooms, and bars. The meetings reported in these volumes were centered about formal papers, but an extremely skilful job of editing creates the impression of listening in on an informal discussion. Best of all, the participants are witty, intelligent people, each exceedingly well informed in his own field but naïve enough in other areas to be fascinated by what the others have to say. The charm of the books lies as much in the participants' personalities, as revealed by the discussions as it does in the content of the discussions themselves.

The WHO Study Group consists of 14 people, whose

backgrounds are in such diverse fields as psychiatry, psychoanalysis, psychology, anthropology, ethology, electrophysiology, and human biology. To each meeting there are invited a few guests who, along with selected members of the group, present papers. A half day is devoted to the presentation and discussion of each paper. In these 2 volumes are thus included papers on physical anthropology, ethology, electroencephalography, developmental psychology, animal behavior, cultural anthropology, and electronic models of human behavior.

The group seldom permits a speaker to complete his presentation without questions for clarification, challenges of data, disagreements of interpretation, and just plain digressions. All of this makes fascinating reading, because the participants are keenly critical and seldom let the speaker get away with fuzzy ambiguous statements. The discussions are informative because many of the comments are based upon not yet published research, unpublished details of earlier studies, or upon pertinent anecdotal material.

The discussions are illuminating also because they reveal how naïve each of us can be outside of his own specialty. Careful physiologists can make the most outlandish anthropomorphic interpretations of behavioral data; excellent psychologists can ask physiological questions that the biologist clearly thinks is nonsense. Cultural anthropologists can let their bias against heredity lead them almost to deny species differences among animals, and specialists in animal behavior seem prone to find species differences in cultural diversity.

So the books make good reading. What else they accomplish is more difficult to say. Since the papers were prepared for oral presentation, they do not have the scholarly documentation of written articles. The comments in the discussion frequently refer to sources that are not identified in the bibliography. The function of these volumes, however, is stimulation rather than information. If research workers and students in child development read them, they will not find a systematic coverage of any of the fields discussed, but they should be stimulated by the potential contributions of research areas generally neglected in textbooks of child development. If the volumes accomplish this result, they are eminently worthwhile, but even if they do not, one can hardly wait to find out what the group is going to talk about next time.

ALFRED L. BALDWIN

HUMAN BIOLOGY

ARAUCANIAN CHILD LIFE AND ITS CULTURAL BACKGROUND. *Smithson. misc. Coll., Vol. 133, Publ. 4297. By Sister N. Inez Hilger. Smithsonian Institution, Washington. Free upon request.* xx + 439 pp. + 10 tables + 80 pl.; text ill. 1957.

No characterization of this book is more suitable than the words of M. W. Sterling, Director of the Bureau of American Ethnology, Smithsonian Institution, who says, in a Foreword: "In this day when the vogue in ethnology is to stress theory and far-reaching comparisons, it is refreshing to find a study that is essentially descriptive. With characteristic energy Sister Inez has gathered a wealth of detailed facts concerning all aspects of child life, biological and sociological, which should serve as a mine of source material for future workers. Essentially she has followed the same methods ... used in her two previous monographs on the child life of the Chippewa and the Arapaho, but in this instance she has stressed even more the cultural matrix which to such a large extent has determined the practices connected with the development and socialization of the child. The approach technically has not been that of the psychologist, but a wealth of psychological material emerges. The abundance of direct quotes from informants and the frequent recounting of personal experiences give to the narrative an intimacy that not only makes it entertaining reading but imparts a human quality which adds to its value as a sociological and psychological document. Considering the importance of the Araucanians, there are not too many accounts available in the English language, and no other study concerning child life.... This study of Araucanians of Chile and Argentina, using the development and training of the child as a method of approach, ... gives an excellent picture of Araucanian ethnology in general as it is today."

Nearly all of the 80 plates contain 3 or more illustrations. Appendices include a list of utilized plants and a second list of mammals, birds, fishes, and shellfishes, with identifying scientific designations. The bibliography covers 18 pages and the double-columned index more than 16 pages. This ethnography and the descriptions of Chippewa and of Arapaho child life and cultural background were published in the period 1951–1957. It is doubtful that in this time span the sum total of comparable published information, in English, equals in quality or in quantity the intimate, discriminating, and illuminating accounts contributed by this author.

WILSON D. WALLIS

THE SCIENTIFIC STUDY OF SOCIAL BEHAVIOR. *By Michael Argyle. Philosophical Library, New York.* $6.00. xi + 239 pp. 1957.

In this analysis and evaluation of studies of groups (mainly small) made during the past 60 years, the critiques are concise, but adequate. The author believes it "just as possible to find valid empirical laws in the

social sciences as it is in physics and chemistry." Special attention is given to the logical features of the various experiments or observations.

The following excerpts will serve as indications of the conclusions or points of view put forward: "In sociology . . . it is early to theorize: elsewhere [in social science disciplines] theory can act as a valuable guide to empirical research, and as an integrator of the results obtained." "When social research acquires mathematical precision it will be time to abandon ordinary language." "The important thing is not merely to produce machinery which will ape human behavior, but to think of models which will explain existing results and predict new ones." "Sociology of to-day is not concerned with a subject-matter that is irreducibly different from that of the psychology of to-day."

Throughout the book there is emphasis that the results of tests and experiments cannot be assessed unless the interpretations are validated.

I know no other book dealing with these matters that is of comparable merit—if, indeed, there is one at all. An amazing amount of information and interpretation is compressed into these pages. There are 24 pages of references, an extensive list of names, and an index.

WILSON D. WALLIS

ANCIENT MAN IN NORTH AMERICA. *Fourth Edition.* *By H. M. Wormington. The Denver Museum of Natural History.* $5.25. xviii + 322 pp. 1 folding map; ill. 1957.

Since the issuance of the first edition in 1939 this book has been standard in its field. This revised edition, bringing finds and interpretations up-to-date, will be welcomed by all who have a penchant for such matters. The author agrees with "the great majority of archaeologists" that there is no evidence which must be accepted as demonstrating the presence of man on this continent before glacial pre-Wisconsin times, the earliest probable date being about 20,000 years ago.

There are 72 excellent figures, most of them containing several illustrations, a section of Illustrations and Definitions of Certain Key Projectile Point and Knife Points, an extensive bibliography, and an excellent, detailed index.

WILSON D. WALLIS

DEMOGRAPHIC ANALYSIS. *Selected Readings.* *Edited by Joseph J. Spengler and Otis Dudley Duncan. The Free Press, Glencoe.* $9.50. xiii + 819 pp.; ill. 1957.

These selections, chosen almost entirely from journals and series and representing views of responsible authors, cover a wide range of demography, and treat of many phases and many problems of the field: historical, economic, and social. The 2- or 3-page introductions to the respective sections are actually summary essays, and are far superior to editors' introductions in most compilations of source materials.

The editors have done a disservice in omitting from each selection identification of author by more than name, and in giving no indication of source or of year of publication. To find these desiderata, the user of the book must consult a list of contributors, placed at the end of the volume, then hunt through 3 pages at the front of the volume which lists the sources alphabetically, and gives author, source, and year of the original publication. They could not have made the search more difficult.

Perhaps, too, we could have been spared such remarks as the following truisms: "Each member of a population . . . must ultimately die once and only once . . . The risk of childbearing . . . applies only to women of a certain age . . . , of whom some have no child, and others several children" (p. 145). And again: "A woman cannot become the mother of a third child unless she has already borne two—just as she cannot be married three years until she has been married two" (p. 152). Or perhaps such challenging statements are intended to rouse the somnolent reader.

WILSON D. WALLIS

THE BAYOU GOULA SITE. *Iberville Parish, Louisiana. Fieldiana: Anthropol., Vol. 47, No. 2.* *By George I. Quimby. Chicago Natural History Museum, Chicago.* $1.75 (paper). 79 pp.; ill. 1957.

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

ASPECTS OF RIVER POLLUTION. *By Louis Klein; chapters by J. R. Erichsen Jones and H. A. Hawkes. Academic Press, New York; Butterworths Scientific Publications, London.* $14.50 xii + 621 pp.; ill. 1957.

In American waste control and stream sanitation practice, this book promises to be most useful to workers in problems of the wastes of chemical industries. Chapter 9, on Detection and Measurement of River Pollution, is an excellent review of current, practical analytical methods for field and laboratory checking of specific industrial waste components. This, together with the comprehensive bibliography at the end of the section, is a substantial contribution. The commentary that runs with the review shows an active understanding of the operation of waste engineering enterprises.

The biological examination of waste-bearing waters

and wastes, in Chapter 8, Biological Aspects of River Pollution, a special section written by H. A. Hawkes, is spread thin and wide. The effort to be comprehensive is obvious, and the treatment suffers from the drive to be specific and to be general at the same time. In justice, it should be said that it is much more difficult to present a useful description of the ecology and of animal and plant societies in the varieties of clean and polluted waters than it is to develop the engineering and analytical phases of the problem. Aquatic biologists readily recognize changes associated with increasing or decreasing pollution, but it is difficult to "design" treatment and other abatement measures from biological records. For this reason, the waste abatement engineers in this country have come to prefer chemical and biochemical observations that yield quantitative values.

A related section, on Fish and River Pollution by J. R. Erichsen Jones, treats the common mineral pollutants in some detail as physiological systems. While few of the species of fish studied have economic significance in this country, the approach that is represented promises better basic information than the standardized systems of biotesting that have been recommended here. Unfortunately, few physiologists are currently interested in industrial waste problems and water-borne wastes.

Other sections dealing with the abatement of pollution and the treatment of sewage and industrial wastes also suffer from an effort to be too inclusive. The treatments are necessarily too general and brief for the practicing waste-abatement worker, and are unlikely to be comprehended by the inexperienced.

The excellent section included in Chapter 8 on the detection of pollution and analytical methods readily justifies the book. Another compensating feature is the inclusion of full bibliographies with each of the 15 chapters.

CHARLES E. RENN

WORK NOTES ON COMMON STATISTICAL PROCEDURES *By F. R. Hayes and D. Pelluet. Scholar's Library, New York.* $2.30 (paper). vii. + 60 pp.; ill. 1958.

THE QUARTERLY REVIEW OF BIOLOGY publishes critical reviews of recent researches in all of the special fields of biological science. The contribution should present a synthesis or digest of the researches and a critical evaluation of them. A mere synopsis of the literature without evaluation or synthesis is not desirable.

Theoretical papers are published occasionally, especially when such papers (1) include a critical synthesis of the literature bearing on the theory and (2) are likely to promote further research in a given field.

The article should be written in concise language, yet in sufficiently non-technical form as to be intelligible not only to specialists in other fields but to the general biologist as well. To this end the article should have a general introduction and a summary which enumerates one by one all of the principal facts and conclusions given in the paper. Interpretative diagrams and schemes are very desirable.

Material ordinarily taking the form of footnotes is set in small print and placed in the text and consequently should be written in a style so as to fit readily into the text. Acknowledgments are printed in the text in small type at the end of the article just preceding the List of Literature. Recent issues of the Quarterly should be examined for style as regards (1) section or subsection headings in the text, (2) literature citations in the text, and (3) List of Literature.

The subjects and authors of articles are selected by the Editors and members of the Advisory Board. Unsolicited articles which conform with the objectives of the Quarterly will be considered for publication.

A feature of the REVIEW is the section dealing with *New Biological Books*. In this department the book literature of different countries in the field of Biology is given comprehensive and critical attention.

The QUARTERLY REVIEW OF BIOLOGY is issued in March, June, September and December.

The reprint order blank accompanying galley proofs gives the cost of reprints.

Manuscripts may be sent to Dr. H. B. Glass, Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland.

Books for Review may be sent to Dr. H. B. Glass, Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland.

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